INTRODUCTORY ESSAY

TO THE

STUDY OF FORTIFICATION.

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STUDY OF FORTIFICATION,

FOR

YOUNG OFFICERS OF THE ARMY.

BY

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PREFACE.

THIS ESSAY is intended for Young Officers. The principles and maxims of Permanent Fortification are first introduced. Then these principles are explained as applicable to Field Fortification—upon which subject the Author enlarges—and the Essay concludes with a popular description of the mode of attacking a fortress, and of reducing fortified posts and villages.

But it must be thoroughly understood that, in order to obtain an intelligent knowledge of the whole subject, an officer must proceed to study larger and more elaborate works; and especially that he should make himself acquainted with the principles of the great arm of Artillery, without which, no enlarged conceptions can be formed of the powers either of attack or defence. It is Artillery combined with Musketry, that animates military works; and such is the present power of artillery that it may be safely said to

be double what it was when the great masters of the art, Vauban, Coëhorn, Bousmard, &c., wrote their able Treatises on Fortification.

☞ *The Reader will be so good as to observe, that, in referring to the Atlas of Plates for this Essay, he will not find the Plates and Figures in them to be consecutively numbered. These Plates have been selected from the Author's larger Treatise on Fortification and Artillery, and transferred to this smaller Atlas, as illustrative of the Elementary Subjects treated of in this Essay. The Plates numbered I, VII, VIII, IX, and X, of the larger work, form the Atlas of this Essay.*

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PERMANENT FORTIFICATION.

PART I.

INTRODUCTORY ESSAY

TO

THE STUDY OF FORTIFICATION.

PART I.

CHAPTER I.

DEFINITIONS AND TECHNICAL TERMS.

1. THE pupil must not be discouraged, in commencing this subject, by finding a number of definitions and technical terms arranged before him; they must be met, and mastered, in order to render what follows easy and intelligible. There are terms and definitions which will occur in the subject at large, which are not to be found in this chapter; but those that follow should be at once familiarly acquired.

2. *Fortification;* is the art of constructing military works, either for defensive or offensive purposes; these works are of two kinds, viz., Permanent and Field Fortification.

3. *Permanent Fortification;* consists of works of a permanent character for shutting in a piece of ground or a city, in the most advantageous manner, in order to make the greatest possible resistance, with a garrison proportioned to its size, against the attacks of superior numbers.

4. *Field Fortification;* has for its objects the protecting or fortifying of camps, villages, houses, passages of rivers, and the construction of such works as may be required to aid the operations of troops in the field, either in the defence or attack of positions; and intended to last only for the day, week, month, or for the campaign.

5. Every piece of ground to be fortified, is surrounded by a polygon, either regular or irregular, upon the sides of which the works are constructed: see fig. 1, Plate I; the dotted lines *a, r, q, b, c, d,* form this imaginary enclosure or *polygon of fortification:* the length of the sides *a r, r q, q b, b c, c d, d a,* are generally regulated by the necessity of the works being mutually within the range of the defensive weapons.

6. The defensive works, in permanent fortifications, consist of *ramparts, parapets* and *ditches.* In fig. 1, Plate I, the ramparts are the lighter shaded masses, the parapets the darker shaded, and the ditches the unshaded portions.

7. All the works constructed on any one side of the polygon form *a front of fortification:* thus, there are six fronts in fig. 1.

8. The succession of lines that show the figure of the works, and indicate the direction in which the defensive masses are laid out, is named the *outline* or *tracing:* in fig. 1, it will be observed that there are no curves; the tracing of the works is in straight lines forming angles with each other.

9. An angle formed by two lines of works meeting and pointing towards the country is a *salient angle;* if the angle points inwards it is a *re-entering angle.*

10. The general height to which the works are raised, is called *the relief:* if the works be generally high and commanding, they are said to have a bold relief; if the reverse, they have a low relief.

11. In several lines of work, covering the same ground, the inner line is usually the highest, and the difference of level between it, and a lower work before it, is termed *the command*, of the one over the other. Thus, in fig. 3, Plate I, where the line *c*, *x*, *p*, *y*, indicates the level of the ground, the height of the inner work or bastion is 22 feet above the level of the ground; and the outer one or glacis, is 8 feet: hence the command of the inner over the outer work is 14 feet.

12. The general level of the ground, or ground line, upon which the works are constructed, is called the *plane of site*, whether that plane be horizontal or oblique to the horizon; as in Plate I, figs. 3 and 4, the planes of site are horizontal: in Plate VIII, fig 21, *l h m*, is an oblique plane of site.

13. *A plane of defilade* is a plane supposed to pass through the summit or crest of a work and parallel to the plane of site. Thus, the dotted line in fig. 4, immediately under the words, curtain, tenaille, ravelin, (being parallel to the ground) may represent a plane or defilade.

14. *A plan* shows the tracing (definition 8); also the horizontal lengths and breadths of the works, the thickness of the ramparts and parapets, the width of the ditches, &c.: it exhibits the extent, division, and distribution of the works; but the depth of the ditches, and the height of the works, are not represented in a plan. Thus, fig. 1, Plate I, is a plan of a fortress on a small scale: and fig. 2, is a plan of two fronts on a larger scale.

15. If a plane pass through a work in any direction, the cut made by it is a *section;* if the cut be vertical and perpendicular to the face of the work, it is a *profile.* If horizontal at the base of the work, it is a *ground plan.*

16. Two things are to be considered in a fortress—the

tracing and the relief: the tracing shows the manner in which the works should be laid out in order to obtain a proper defence; and the relief provides the requisite elevation for the artillery and musketry to ensure this defence.

17. The great mass of earth thrown up from the ditch inwards, in order to give the defenders a commanding surface for their cannon and musketry, is the *rampart;* and the covering shot-proof mass on the exterior side of the rampart, is the *parapet.*——Thus, in examining fig. 3, Plate I, where *c, x, m, p, y,* is the ground line, the earth excavated from the ditch and built up inwards is the rampart; and the men standing on its upper surface *a b,* are covered by a shot-proof parapet *n f, h, i;* having a step of earth *n, d, b,* sufficiently high to enable the defenders standing on it to fire over the crest of the parapet with ease; this step is the *banquette.*

18. Immediately without the ditches of the place, there is a road of communication all round the fortress, usually 30 feet wide; having on its exterior edge a covering mass of earth 8 feet high, which slopes off gently towards the country: this road is *the covered-way,* and the sloping mass *the glacis.* See fig. 3, Plate I, in section: and this covered-way and glacis is represented in fig. 1, in plan, as running all round the outside of the ditches or unshaded portions.

19. The ditches being deep, the banks of earth on each side are supported by masonry walls, of a certain thickness—backed interiorly by buttresses, in order to strengthen them: these walls are called *revetments:* and the buttresses of masonry are the *counterforts.* The side of the ditch next the place, is called the *escarp;* and that next to the country, the *counterscarp.* The top of each wall is covered with a flat stone which is worked into the masonry, and which

usually projects about one foot beyond the face of the wall, and is rounded off in its profile, this is the *coping-stone*, (and serves to protect the masonry from being saturated with rain water); as the revetments are usually built first, and the measurements laid off from this stone on the escarp, it is in plan, called the *magistral* or *master line:* and is represented by a thickly drawn red line, as A H E F G B in fig. 2: the escarp revetment is shown in section at *i k*, in fig. 3, and is 5 feet thick at top, with a section of the counterfort 7 feet thick; the counterscarp at *l m*, with its counterfort 5 feet thick.

20. We will now give the names of the different parts of a rampart, parapet, &c. See fig. 3, Plate I, in profile, *c*, *x*, *m*, *p*, *y*, representing the level of the ground.

a c—Interior slope of the rampart, a base equal to its height, each 14 feet, in this case.

a b—Terre-plein of the rampart, varying from 25 to 40 feet in width.

b d—Slope of the banquette, usually having a base of 1½ its height.

d n—Tread of ditto, from 4 to 6 feet wide.

o f—Interior slope of the parapet, usually equal to one-fourth its height.

f h—Superior ditto, ditto, usually a depression of two inches per foot.

h i—Exterior ditto, usually a base equal to its height or rather more.

i k—Exterior face of the revetment wall of masonry, forming the escarp side of the ditch, usually 30 feet high.

k l—Bottom of the ditch, from 60 to 100 feet wide.

l m—Exterior surface of the revetment wall of masonry

forming the counterscarp side of the ditch, usually from 12 to 24 feet high.

m p—Terre-plein of the covered-way, usually 17 feet wide.
p z—Slope of the banquette ditto, ditto 6 ditto.
z t—Tread of ditto ditto, ditto 5 ditto.
t r—Interior slope of the glacis, ditto 1½ ditto.
r y—Glacis, ditto 150 ditto.

Fig. 2, shows a plan of two fronts on a large scale with the slopes, &c. in detail. The pupil should not leave this part of the subject until he can trace the corresponding parts in plan and in section, and is familiar with all the names and general dimensions.

21. *Embrasures* are openings made in the parapet, for the cannon to fire through; the parapets are usually 7½ feet high: the carriages on which guns rest are 3 feet high, hence the opening or embrasure is at about 4½ below the crest, or 3 from the ground: it is about 2 feet wide at the interior slope of the parapet or the *neck*, and widens or splays outwardly, to allow the gun to range right and left, as well as to render the sides of the embrasure less liable to be destroyed by the explosive force of the gunpowder in each discharge. The embrasure is about 9 feet wide at the *mouth;* and the slopes of the sides or cheeks, are made about one-fourth of their height. See Plate VIII. Fig. 5 is a section of an embrasure; and fig. 6 a plan of the same; with a platform 10 feet wide and 15 feet long, on which the gun-carriage rests: this platform has a slope of ½ an inch per foot, rising to the rear, in order to lessen the action of the gun-carriage in recoiling; at the head of the platform there is a small beam of wood about 6 inches square called the *hurter*, to check the wheels of the gun-carriage and to prevent them injuring the interior slope of the parapet. Fig. 11

shows a plan of 4 embrasures: fig. 11, *a*, an interior elevation, and fig. 11, *b*, an exterior elevation, of the same.——Embrasures are made through the mass of the parapet wherever they are required in permanent works.——Guns in embrasure usually stand at 18 feet apart; the solid portions of the parapets between the embrasures are called the *merlons*.

22. *Barbette.* Guns are said to be in barbette when they are elevated by raising the earth behind the parapet, or by placing them on a high carriage, so that instead of firing through embrasures, they can be fired over the crest of the parapet. In this position, the guns have a wide range, instead of being limited, as in firing through embrasures. A gun may be placed in barbette, by raising the earth for the platform of the gun to within 2 or 3 feet (according to the nature of the carriage on which the gun stands) of the crest of the parapet: or, the ordinary garrison gun-carriage may be placed on a large traversing platform, which will raise it so as to fire over the crest; this is the most common and useful mode of placing guns in barbette. The elevated barbette masses of earth are usually at the salients of the bastions and ravelins. Traversing platforms however are much more convenient, and when it is desirable to remove the guns from this elevated position, and to sink them into embrasure, the quantity of earth forming the barbette mass has to be taken away, whereas the traversing platform is easily and immediately removed. Traversing platforms consist of two large wooden or iron sides, with grooves in their upper surface for the wheels of the common garrison gun-carriage. In Plate I, fig. 13 (*a*), there is a plan and side elevation of a cast-iron traversing platform. F is the pivot on which this iron frame turns or traverses; the front trucks or wheels being marked *r*, and the rear trucks *t*: the parts *p p p* are light iron perforated

plates, on which the gunners stand to load, the man who points the gun being the only one exposed on the upper part of the platform. The position of the pivot F varies, depending on the kind of work from which the gun is used ; if in a round tower, the pivot would be in the centre.——The advantage of guns in barbette is that they can range in all directions, and cover a quantity of ground by their fire: but when an enemy has so far advanced as to come within the range of musketry fire, then the gunners serving guns in barbette are exposed from the loins upwards, and are sure to suffer so severely, as to render it necessary to sink the guns into embrasure, for the better protection of the gunners.

23. The following reasons are given for making the ramparts and parapets of the dimensions specified in paragraph 20, and in the figures 2, 3, and 4, Plate I.

24. Fig. 3, *a c*. *The interior slope of the rampart* has a base equal to its height; in this case, each is equal to 14 feet: this slope, *a c*, makes an angle of 45° with the ground line; and is the natural slope at which earth of common tenacity will stand; and it is thus formed, that it may remain stable without support or repair.*

25. *a o*, fig. 3. *The terre-plein of the rampart.* It has already been shown that the platforms for guns occupy a length of 15 feet, and allowing from 10 to 25 feet (according to circumstances) in their rear, for the free passage of the artillery and the defenders; the terre-plein will then have a width, *a o*, of from 25 to 40 feet. All terre-pleins

* In many fortresses, this slope is cut away, and a perpendicular wall supports the rampart on the inside ; this is done in places where the interior space of the fortress is limited, and when it is desirable to give the inhabitants as much room as possible.—See fig. 4, in the rampart of the curtain.

have a slight slope or inclination to the rear, to keep them drained from rain-water.

26. *o f*. *The interior slope of the parapet* has a base of one-fourth of its height; it is supported by a revetment of masonry, of turf, or of sods; this steep slope is necessary in order that the guns may be run well out into the embrasures; and also that the musketry on the banquette may lean conveniently against it to fire over the parapet. The total height of the crest of the parapet above the terre-plein is $7\frac{1}{2}$ feet, that the men in its rear may be sufficiently covered and protected by it.

27. As guns in battery stand at 18 feet apart, the spaces between their platforms are usually occupied by banquettes; *the tread*, or *terre-plein of the banquette* is raised to within 4 feet 3 inches, or 4 feet 6 inches of the crest of the parapet, that the defenders may fire along its superior slope with ease; its width, *d n*, is from $4\frac{1}{2}$ feet to 5 feet, that there may be room upon it for two ranks of men: although more than one is rarely on it at a time; its slope, *b d*, to the rear, is made gentle that the defenders may ascend and descend with facility.

28. *f h*, fig. 3. *The superior slope of the parapet* has a base of 18 feet, that it may be shot-proof: its slope prolonged (the line of fire of its musketry) should cut about the top of the opposite counterscarp; this depression is usually at the rate of two inches per foot; a greater dip would weaken the crest by making too sharp an angle of earth, which could be easily beaten down.

29. *h i*, fig. 3. *The exterior slope of the parapet* should have a natural slope, to prevent its being worn away by the action of weather and time; and, as it is exposed to receive the shot of the assailants' guns, it is well to give it even a greater base than its height. In this figure the base is greater than the height, by 1 foot.

30. The thickness of the rampart is (from the above),

Interior slope, its base	14 feet
Terre-plein of the rampart (including the banquette)	34½
Interior slope of the parapet	1½
Superior ditto	18
Exterior ditto	12
Total	79

31. *Escarp Revetment, i k,* is made 30 feet high, because this is a height difficult to escalade ; the strength and stability of revetments, and of their strengthening counterforts, will be treated of at large in a more advanced part of the Treatise.

32. *Width of the ditch, k l,* should never be less than once and half the total height or relief of the work : it is usually more.

33. *Counterscarp of the ditch, l m.* This wall should always be so high as to render it impossible, or very difficult, for an enemy to descend into the ditch without ladders: it is here 22 feet high.

34. *The covered-way : m g,* is made about 30 feet wide, as this affords sufficient space for a banquette to the glacis, and for all the necessary operations of the defenders ; who have, in addition, enlargements at the angles, called *Salient* and *Re-entering places of arms.*

35. *The glacis : r y,* is 150 feet in length, and 8 feet high, forming a gentle sloping indestructible bank of earth, exposing all advances to the full sweeping fire of all the works in the rear of it.

36. *The elevation* of a work shows its geometrical dimensions above the ground in the direction in which it is viewed. It is described by horizontal rays or lines passing

from every point of the object, or side of the work viewed, to intersect a given plane: See fig. 11, Plate VIII, which will require, with fig. 11 *a* and 11 *b*, thought and consideration, in order to understand each part clearly, as represented in section, plan, and elevation. In these figures we have the plan and *elevation* of a common battery for guns and mortars: the section is given in fig. 5.

37. The explanation of the term relief having been given in its fullest extent, in paragraph 10, it now remains to point out its more limited signification; the total height of any single work, from the bottom of the ditch to the summit or crest of the work, is the *relief* of that work; for instance, in fig. 3, Plate I, the height of the crest of the bastion from the bottom of the ditch is 44 feet, which is the relief of this work.

38. When a work has a sufficient elevation over the work before it, to enable the defensive weapons to act in both works at the same time, upon an enemy's advance, even to the foot of the glacis, then the inner or higher work has a *command of fire* over the lower work: but if the higher work cannot do this, but has only a sufficient elevation to look into, and act upon, the interior of the outer work, then the difference of level amounts to a *command of observation*. Thus, in figs. 2 and 4, the ravelin has a command of 11 feet over the crest of the glacis before it, which is a command of fire: and the faces of the bastion in figs. 2 and 3, have a command of 14 feet over the crest of the glacis, which is also a command of fire: but the curtain, in figs. 2 and 4, has only a command of 3 feet over the ravelin, which is a command of observation.

39. A *bastion* is a work having two faces and two flanks, the angles being all salient; see fig. 2, Plate I. The angle formed by the meeting of the two faces is the *flanked angle of the bastion*, as B; that formed by the

meeting of a face and a flank is the *shoulder angle*, as G or H ; and that formed by the flank and the curtain is the *curtain angle*, as G F E ; that formed by the meeting of the line of defence and the flank is the *angle of defence*, as G F H. In standing in a bastion and looking towards the country, the face and flank on the right hand is called the right face and flank ; and on the left hand, the left face and flank. See figs. 2 and 5. The mass of rampart and parapet follows the windings of the faces and flanks ; leaving, in some cases, an interior space in the centre of the bastion, on the level of the ground : for example, in fig. 1, Plate I, bastion *b*, all the space within, which is unshaded, is on the level of the ground : this construction is called a *hollow* or an *empty bastion*. In other cases, as in bastions *r* and *a*, fig. 1, the interior space is all filled up to the level of the terre-plein of the rampart ; these are *full bastions*. In fig. 5, bastion P, the distance (*g o*) between the inner extremities of the two flanks, is the *gorge* of the work ; the prolongations of the adjoining lines or curtains, *g p*, and *o p*, are the *demi-gorges*. When the demi-gorges and gorge are in the same line, and the former is half of the latter, the work is called a *flat bastion*.

40. The line of rampart that joins the flanks of two bastions together, is the curtain, as E F, fig. 2.

41. The pupil has now to refer to fig 5, and to its explanatory reference in Plate I ; and make himself fully acquainted with the names of the different works ; of the various lines and angles throughout. The dotted lines are merely lines for guidance, they do not exist in the practical construction of the work : the thick lines, in fig. 5, indicate the escarp of the body of the place : the thin lines, the counterscarp : this figure represents a square, with a bastion at each angle. The pupil, after having well examined the plan and reference, had better question himself somewhat,

as follows :——*Question.* How is the flanked angle of the bastion formed ?—*Answer.* By the meeting of the two faces.

Q. How is the shoulder angle of the bastion formed ?—*A.* By the meeting of a face and flank.

Q. How is the angle of defence formed ?—*A.* By the meeting of the line of defence and the flank.

Q. How is the diminished angle of the polygon formed ? —*A.* By the meeting of the exterior side of the polygon and the line of defence.

And so on, throughout, until all these useful technicalities are familiar.

42. *The ravelin,* or *demi-lune,* is a work having two faces forming a salient angle, placed beyond the main-ditch opposite to the curtain, and separated from the covered-way by a ditch that runs into the main-ditch, see fig. 2.

43. *Places of arms* are enlargements in the covered-way at the re-entering and salient angles of the counterscarp ; hence the terms *re-entering places of arms,* and *salient places of arms ;* the latter space is formed simply by rounding the counterscarp : and the former by setting off demi-gorges of 30 yards (more or less), and making the faces form angles of 100° with the adjoining branches of the covered-way : see fig. 2.

44. *Traverses* are portions of parapet thrown across the covered-way, on the prolongations of the faces of bastions and ravelins, and at the entrance of the re-entering places of arms ; passages are cut into the glacis, to enable the defenders to circulate round the traverses. See figs. 1 and 2.

45. *The tenaille* is a low work in the main-ditch, before the curtain and between the flanks of the half bastions of a front of fortification ; it is usually 16 yards in thickness, and reveted with masonry all round. See figs. 2 and 4.

46. The first belt of ramparts and parapets that enclose the place is *the body of the place ;* those works placed

beyond the body of the place, but within the glacis, are *outworks.* In fig. 2, the bastions and curtains form the body of the place, or the *enceinte:* the tenaille, the caponier, the ravelin, and the covered-way, are outworks.

47. *Advanced works* are such as are constructed beyond the covered-way and glacis, but within the range of the musketry of the main-works. *Detached works* are those which it sometimes becomes necessary to construct beyond the range of the defensive musketry of the main-works; and as a constant and steady communication with them cannot be kept up during a siege, they are consequently left chiefly to their own resources; nevertheless, they ought to exercise a general influence on the defence of the place.

48. *A caponier* is a parapet from $7\frac{1}{2}$ to 10 feet in height, having its superior slope terminating in a small glacis: it is placed in a dry ditch, in order to cover the defenders in passing across the ditch from one work to another, and it has a banquette, to furnish a fire of musketry upon the ditch. See figs. 2 and 7.

49. *A cunette* is a small ditch in the middle of a dry ditch, in order to keep it drained.

50. *A batardeau* is a strong wall of masonry built across a ditch, to sustain the pressure of the water, when one part is dry and the other wet: to prevent this wall being used as a passage across the ditch, it is built up to an angle at top, and armed with iron spikes; and to render the attempt to cross still more difficult, a tower of masonry is built on it: in the batardeau is the sluice-gate, by the opening or closing of which the manœuvres of the water can be regulated.

51. *A citadel* is a small strong fort, constructed either within the place, or on the most inaccessible part of its general outline; it is intended as a refuge for the garrison, in which to prolong the defence after the place has fallen,

or to hold out for the best terms of capitulation. Citadels are generally in positions that command the interior of the place, and are therefore useful in overawing a population that might otherwise strive to shorten the length of a siege, during which the inhabitants are always great sufferers.

52. The quantity of earth or soil contained in the mass of the rampart and parapet of a work is called, the *remblai;* and the quantity excavated from the ditch, the *deblai:* and, in general, the number of cubic yards contained in the remblai has been furnished by the deblai; so as to balance each other.

53. There is great variety in laying out or tracing the works of a fortification: depending sometimes on the nature of the ground, and more generally upon the professional opinions of the different masters of the art: hence the pupil will expect to meet with *a great many Systems or Methods of Fortification.*

54. *Range of fire-arms.* The ranges of musketry and artillery, as well as the penetration of the shot projected from them, greatly affect the arrangement and solidity of defensive and offensive works. We therefore proceed to state that the effective range of ordinary musketry is from 180 to 200 yards; but at 300 yards it is not very efficient.

Rampart-muskets, or wall-pieces, are used in the defence of works, and are effective at from 400 to 500 yards.

The following are the ranges of artillery in common use—

FIELD ARTILLERY.	Ranges in yards.	
	At point-blank.	At 4° of elevation.
6-pounder gun..	200	1200
9 or 12 do. do...	300	1400
12 do. howitzer	200	1000
24 do. do....	250	1025

HEAVY ARTILLERY.	Ranges in yards.	
	At point-blank.	At 4° of elevation.
18-pounder gun	360	1600
24 do. do..	360	1670
32 do. do..	380	1730
		12° of elevation.
8-inch howitzer		2000
10-inch do.		2410

The extreme range of small brass mortars, called *Royal*, or *Coëhorn*, is about 600 yards ; of the 8-inch iron mortar, 2000 ; of the 10-inch, 2400 ; of the 13-inch, 2900 yards.

The heaviest description of artillery, such as 56-pounders, the 8 and 10-inch guns, fired at considerable elevations, range to distances of 4000 to 5000 yards.

55. *Penetration of shot from fire-arms.* It is known, from experiment, that the penetration of missiles into a common bank of earth is as follows ; which will require a thickness of parapet somewhat greater.

Penetration in feet at a mean range.	In the superior slope. Proper thickness of parapet in feet.
Musket-ball $1\frac{1}{3}$	3
6 pounder $3\frac{1}{3}$ to $4\frac{1}{3}$	6
9 ditto $6\frac{1}{3}$ to 7	9
12 ditto $8\frac{1}{3}$ to 10	12
18 and 24 ditto $11\frac{1}{3}$ to 13	18

In the defence of villages, the walls and barricades to resist musketry must be of sufficient substance. A good 9-inch brick wall ; 6 inches thick of stone ; 12 inches thickness of fir ; 4 or 5 inches of oak, will do so.

56. *Shot and shell can be projected from ordnance in eight ways.*

a	Direct fire.	*e*	Reverse fire.
b	Oblique fire.	*f*	Ricochet fire.
c	Enfilade fire.	*g*	Vertical fire.
d	Slant fire.	*h*	Pitching fire.

a *Direct fire,* is when the battery of guns is ranged parallel to the face of the work, or the line of troops, to be fired at ; so that the shot strike it perpendicularly : direct fire is the best for breaching, and is very destructive against advancing or retiring columns, which have a narrow front and considerable depth.

b *Oblique fire,* is when the battery of guns is ranged

so as to form an angle with the front of the object to be struck: against a wall this is inefficient, for a shot striking its face obliquely, glances off without doing much injury; against lines of troops it is not so effective as enfilade, but it is still formidable upon columns.

c; Enfilade fire, is when the battery is ranged perpendicularly to the prolongation of the crest of a parapet, or to a line of troops, so that the shot flies in the same direction as the line, sweeping along from one end to the other. This is a most formidable and destructive fire, either in the attack and defence of works, or in the field.

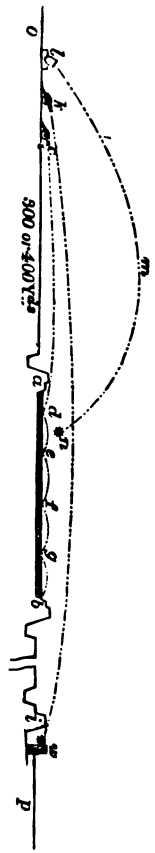
d; Slant fire, is when the shot strikes the interior slope of the parapet, forming with it a horizontal angle not greater than 30°.

e; Reverse fire, is when the shot strikes the interior slope of the parapet at an angle greater than 30°.

f; Ricochet fire. Here the guns are in the same position as for enfilade, being fired with small charges of powder, and having an elevation: either shot or shell may be used. In sieges it is of the first importance to clear the enemy from the faces of the works that look upon, and command, the ground of attack, and to silence their artillery by breaking down and destroying the gun-carriages; for which purpose enfilading batteries are erected, so as to rake the terre-pleins of the works from one end to the other; but supposing a battery to be so placed as to be perpendicular to, and bearing upon, the terre-plein of any line of rampart, it is always hidden from view by some intervening rampart and parapet (probably running parallel to the battery); then if a shot be fired with a full velocity, so as to graze the top of the intervening parapet, it will pass over the heads of the men and guns on the terre-plein; but if the enfilading guns be loaded with small charges, and fired at small elevations, the shot can be made to graze just in front of

the obstacle, then to bound over it, and along the interior terre-plein ; and although the force will not be so great as with shot fired with the usual charges, it will be sufficient to disable gun-carriages and men, which is all that is required : and common shells, bursting in this manner, have their full effect.——In firing at troops, ricochet is very effectual ; since, if a shot misses on the first graze, it will probably make seven or eight more, and, amongst a crowd, every one will tell ; whereas, with the full charge, the shot may pass over the heads of all.——It is worthy of notice, that, with these small charges, neither the guns nor carriages suffer so much as with full charges, and the expenditure of ammunition is not so great.——This species of firing is not confined to any particular charge or elevation : each must vary according to the distance and difference of level of the object to be fired at ; and particularly of the spot on which it is intended the shot shall make the first bound. The smaller the angle is, under which a shot is made to ricochet, the longer it will preserve its force and have effect : and as it will sink so much less in the ground on which it bounds, the resistance to the shot's progress will be lessened proportionably. In the ricochet of a fortification of any kind, the angle of elevation should seldom be more than 10° to throw the shot over a parapet a little higher than the level of the battery. If the works should be of an extraordinary height, the piece must be removed to such a situation, and have such a charge, that it can attain its object at this elevation, or at least under that of 13° or 14°; otherwise the shot will not ricochet effectively, and the gun-carriages will suffer very much. In the field, the objects to be fired at being principally infantry and cavalry, the guns should seldom be elevated above 3°: as with greater angles the ball would be apt to bound too high and defeat the object intended.

g; Vertical fire. Mortars are fired with an elevation of 45°, and the shells projected from them, form a high curve in their flight in the atmosphere: the shells are made to burst and scatter destruction around.



h; Pitching fire. This is done by projecting shot or shell against a wall to be destroyed, which is covered in front by a mass of earth, over which the shot is projected and pitched against the face of the wall: a succession of shells, filled with gunpowder, thus bursting against the face of the wall soon effect a breach.———There is no difficulty in understanding what is meant by direct, oblique or slant fire; or even enfilade: but to young students, ricochet, pitching and vertical fire, may be further illustrated by the annexed diagram.——Suppose *o p* to be a plain of 1000 or 1500 yards in extent: let *a* and *b*, be sections of two fronts facing different ways, but both parallel to the distant guns of an enemy, *c, k, l*: let the shaded portion from *a* to *b*, represent a line of rampart and parapet connecting the fronts *a* and *b*—and that the gun *c*, is precisely on its prolongation of its terre-

plein—if a shot or shell be projected from the gun *c*, so as to graze the crest of *a*, and to fall on the enfiladed face at *d*, then it will bound along its terre-plein at *e*, *f*, *g*, and *b*; this bounding is ricochet.——Again, suppose a wall *w*, covered by a bank of earth at *i*; let the guns at *k*, project shot and shell so as to graze *i*, and *pitch* against *w*: this is pitching fire.

Let *l*, represent a mortar firing with 45° of elevation, the shell in its flight forming the curve *l*, *m*, *n*: the shell, filled with gunpowder, being contrived so as to burst as it reaches the ground; this is vertical fire.

57. Certain simple preliminary geometrical problems must be well known and practised before the student can venture on drawing a plan. Such as—

1. To divide a straight line of given length into any number of equal parts.
2. To bisect a given line.
3. To raise a perpendicular to a given line from any point in it.
4. To let fall a perpendicular on a given line from a given point, outside the line.
5. To make an angle equal to a given angle.
6. To bisect a given angle.
7. From a given point outside a circle, to draw a tangent to the circle.
8. To construct a square; a pentagon; a hexagon; and an octagon, on a given line;

and other simple problems of this kind.

Also, to handle and use with ease and intelligence, a set of Marquois scales; a scale of chords, &c.

He must also practise the drawing of scales on paper. See specimens of scales in the foot of Plate I. Those of a large kind, as 4 feet and under to 1 inch may be divided into halves and quarters, as seen in specimen No. 1. Scales

from 4 to 10 feet to an inch, may have their units subdivided into halves; see specimen No. 2. Scales from 10 to 40 feet to an inch, to be divided into units and tens; see specimen No. 3. Scales from 40 feet and upwards to an inch, to be divided into tens and hundreds; specimen No. 4. Scales for outlines may be in a single simple line, as specimen No. 5.

In plans, feet are represented by ′, and inches by ″.

CHAPTER II.

NECESSITY FOR USING THICK EARTHEN RAMPARTS AND PARAPETS. CONSTRUCTION OF VAUBAN'S FIRST SYSTEM. PRINCIPLES OF TRACING VAUBAN'S FIRST SYSTEM.

58. *Necessity for fortifying with the present thick earthen ramparts, parapets, &c.*—Before the knowledge of gunpowder, which has rendered artillery so tremendous an engine in all kinds of modern warfare, but more especially so in the attack and defence of fortified places, the mode of fortifying was simple, but quite adapted for defence against the implements then in use; which however ingenious and formidable at that time, sink into insignificance when compared with the irresistible missiles now projected from guns and mortars, by the power generated from the explosion of gunpowder.

59. A thick wall flanked by towers, separated by a ditch from the country, constituted the whole of an ancient fortification.* The towers were within bowshot of each other, and raised one or two stages above their connecting walls, in order to preserve a command over the latter, should an enemy make himself master of them; as well as to obtain a height sufficient to contend with the great moving

* This rampart wall had, upon its exterior edge, a thin battlemented or loop-holed parapet, to serve as a cover for the archers, and to permit them to fire through. And in most cases this parapet was projected like a balcony, having loop-holes in its base, to enable the besieged to see and to defend the bottom of the rampart wall. This balcony was called machiacoulis, and forms the picturesque projection of old towers as seen at this day: see Plate VIII, fig. 37 B, and fig. 39.

towers then used in the attack: these flanking towers were sometimes partially separated from the curtain walls by a cut, having a drawbridge: thus they answered as rallying posts and citadels which required to be attacked, even if the walls connecting them were carried; hence the attack was nearly always carried on against a tower in preference to the curtain wall. To become master of such a place (after having reached the counterscarp or outer edge of the ditch), a portion of the ditch was filled in, and a good causeway made across it, to allow of the battering-rams being brought up to beat down the walls; while showers of stones and arrows were kept up from both sides.

60. On the introduction of cannon, the shot projected from which can beat down masonry at a distance of many hundred yards, the old high frowning battlemented walls no longer afforded security, as breaches or openings could be made in them without the necessity of bringing the breaching batteries (as with the battering rams, &c.) close up to the wall; and in the attack, the great moving towers, and most of the other contrivances were of necessity laid aside, as the shot from the defensive batteries could break them to pieces. A total change, therefore, became necessary in the construction of defensive works, and in the mode of conducting the attack, in order to suit the new kind of artillery and its wonderful agent, gunpowder. This agent was discovered about the year 1320, although it was not till 1380 that its power was sufficiently ascertained and regulated, to make artillery so formidable as to create a necessity for an entire revolution in the defence and attack of fortified places. In the advance of the mechanical arts, which have, of late, brought almost to perfection the manufacture of gunpowder, the casting and boring of guns and mortars, the construction of carriages and implements necessary in the transport and use of artillery, the value of

this arm has become proportionably greater, and its influence almost paramount in the branch of warfare of which we are now treating. Hence the old narrow rampart wall has naturally given place to one of earth of greater breadth and less height: and although it is faced exteriorly with masonry, yet no part of the latter should be seen from the country: for in viewing a well-constructed place from without, the masonry ought to be so well covered, that an observer could see nothing but one shot-proof earthen parapet rising one over another. Hence the assailant is forced to bring his battering guns, by a toilsome and dangerous process, to the counterscarp of the ditch, in order to make a breach or opening in the scarp revetment. The thin parapet of masonry that sufficed formerly to cover the archers and slingers, could be immediately cut through by shot projected by gunpowder: and if it were sufficiently thickened to be shot-proof (8 feet), it is very undesirable to make it so; since the splinters detached from masonry walls by shot striking them, are at all times very dangerous, and do much execution amongst those who are near them. A parapet of earth has therefore superseded that of masonry; and as the shot from heavy guns can penetrate from 12 to 15 feet into a bank of earth, the thinnest part of the parapet at top is made 18 feet, and its base occupies from 25 to 30 feet.

61. By being placed behind a massive earthen parapet, the defenders are so far removed from the ditch before them, that it is impossible for them to see or to defend it: as in fig. 3, Plate I, the superior slope of the parapet, *f*, *h*, prolonged (the line of their fire) only cuts the top of the opposite counterscarp; such a defect as an undefended ditch, or piece of *dead gound*, must not, if possible, be permitted to exist within range of the defensive weapons, even outside of the place, but assuredly not in the ditches; in which an

enemy may either collect in force, or employ his miners to penetrate the rampart and blow it up: it therefore becomes necessary to trace the works so as to obviate this defect.

62. If a parapet be traced in a straight right line with a ditch before it, then it is evident that the ditch is wholly undefended by the fire of the parapet. If to obviate this, the tracing be as seen in fig. 8, (where the shaded part represents the parapet) in the redan from *p r s;* and suppose men placed at *g* and *h* with muskets leaning over the superior slope of the parapet, their shot would probably strike the bottom of the ditch at *k* and *i*, defending or flanking it on each side up to the angle at *r;* but the space *p k*, *s i*, in the ditch would still be unflanked; this redan tracing, therefore, is not a sufficient remedy for unflanked ditches, and is inapplicable to perfect works; and it will be found that there is no other mode of defending ditches from behind thick parapets but the bastion tracing.—— Fig. 1, Plate I, front *c d*, shows this; the men placed on the flank, 8, see the bottom of the ditch from *h* to *d:* and the men on the banquette 10, see the bottom of the ditch from *h* to *c*. Thus the musketry fire of the men on the flanks 8 and 10, secures a perfect defence for the whole of it, meeting on the perpendicular *h*, at the bottom of the ditch. (The lines of fire are here drawn to illustrate the subject.)

63. The mass of rampart and parapet, and also the main-ditch, follow the windings of the lines called bastions, and curtains; and this first enclosure is the body of the place: on it the heaviest ordnance is mounted for the defence; but, by examining the nature of the defence produced by such a simple enceinte, with a covered-way before it, (as in fig. 1, fronts *b c*, and *c d*,) it will be seen that something more than this first line of works is necessary; for suppose, in this figure, that the defenders on the faces of

angle, describes arcs intersecting the lines of defence; chords to these arcs give the flanks, G F, H E, of the bastions; and a line joining the inner extremities of the flanks will give the curtain E F.

67. To trace the main ditch, describe an arc of a circle from the flanked angle of each bastion, with a radius of 30 yards when the ditch is dry, and 36 yards when it is wet; lines drawn as tangents to these arcs from the shoulder angles of the collateral bastions, give the counterscarp.

68. To trace the ravelin, set off for the capital 100 yards I K from the re-entering angle of the counterscarp, I, of the main ditch, along the right radius, in order to fix K the flanked angle of the ravelin; from this point K, the faces are directed to points at 10 yards from the shoulder angles of the bastions in the rear, taken along the faces. The ditch of the ravelin is 20 yards wide; the counterscarp being drawn parallel to the escarp.

69. The faces of the tenaille coincide with those parts of the lines of defence that lie between the flanks of the bastions: its thickness is 16 yards; its extremities or profiles, are parallel to the flanks of the bastions, at a distance of 8 yards; and its rear is parallel to the curtain at 10 yards.

70. To trace the caponier, draw its crest parallel to the perpendicular at 6 yards; and its glacis at 20 yards parallel to its crest; the passage between the demi-gorge of the ravelin and the head of the caponier is 3 yards wide.

71. The breadth of the covered-way is 10 yards, following the windings of the counterscarps of the ditches; at the re-entering angles, set off 30 yards on each side, as demi-gorges for the place of arms; at these points the faces are to form angles of 100° with the original tracing

of the covered-way ; the foot of the glacis is parallel to its crest at 50 yards.

72. The traverses are 18 feet thick ; those at the salient places of arms are formed on the prolongation of the faces of the ravelins and bastions ; those at the re-entering places of arms, are perpendicular to the covered-way : each branch of the covered-way, before the ravelin, has a third traverse, placed mid-way between the salient and the re-entering places of arms. The dimensions of the passages round the traverses are marked on the plan : when all the slopes are in, there should be a space of 9 feet clear all round the traverse.

73. *In order to construct a set of profiles to this system*, the reader is referred to figs. 3 and 4, which represent sections taken on the lines, *u v*, *v x*, *x y*, *y z*, of fig. 2. After these profiles have been drawn, they will afford the means of filling in all the details of the slopes on the right front of fig. 2.

The command of the enceinte over the country is . .	22
ditto over the ravelin . . .	3
ditto over the crest of the glacis	14
ditto over the tenaille . . .	20
The depth of the main-ditch below the level of the ground	22
ditto of the ditch of the ravelin ditto	22
The command of the ravelin over the crest of the glacis	11
The crest of the glacis above the ground	8

In filling in the slopes of the traverses, reference should be made to fig. 6, where every detail is clearly inserted ; the revetment walls having all a slope of one-fifth of their height, they are thus represented in plan and profile.

74. The staircases at the re-entering places of arms are 36 feet in length, and 6 feet in breadth; those at the salient places of arms, before the bastions, are of like dimensions; but before the ravelins, where the space between the traverses is more limited, the staircases may be made as seen before the ravelin on the right front; having a length of 24 or 36 feet, and a breadth of 6 feet: at the gorge of the ravelin, the staircases are 36 feet long, and 6 feet wide; and on the gorge of the tenaille, 30 feet long by 6 feet wide.

75. The ramp along the interior slope of the rampart of the ravelin is 20 yards long, and 4 yards wide; that at the gorge of the full bastion, as well as the flank of the empty bastion, is 36 yards long, and 6 yards wide.

76. The barbettes and embrasures are omitted in fig. 2, in order to keep the plan as simple and clear as possible. Thick lines also, for indicating the crests of the parapets, are omitted in fig. 2.

77. When the situations are considered and examined, in which fortresses are generally constructed, it will be found that the works usually rest upon irregular and unequal ground, or on ground presenting natural obstacles on some sides to the approach of an enemy. Fortresses usually cover commercial marts, dock-yards, harbours, &c., and their defensive properties may be, and generally are, increased from the navigable rivers, islands, marshes, or commanding positions, that are to be met with in such cases. When some sides of a place are inaccessible or very difficult of access, from these, or from other causes, it would be quite needless to present there a succession of fronts of bastions, ravelins, and covered-way; such sides require only to be enclosed by a single rampart with artillery in barbette or embrasure, to command the obstacle or the

ground beyond it; while fronts liable to be attacked are protected by an accumulation of works and artificial difficulties: and for these reasons almost every existing fortress is irregular.

78. In examining the works of Vauban, it is found that, in the general outline, he used various lengths for the sides of his polygons of fortification, which have been accordingly classed into *great, mean, and small fortification;* and as some general principles are to be traced through the whole of his works, it will serve to illustrate the subject if the investigation of his first method* be arranged under the following heads:—

a The general outline and form of the works.
b The lengths of the various lines and works.
c The openings of the different angles of the works.

79. *a, On the general outline.* From the remarks just made, it follows that the assailable fronts of a fortress should be carefully and perfectly constructed, and that those covered by natural obstacles will suffice, if barely enclosed by a single line of works: accordingly, in examining most existing places, this is found to be the case; the general outline presenting some long simple fronts, either crowning heights, or covered by rivers, marshes, &c.: the fronts liable to attack are of a medium length, having a careful tracing and relief, with a regular system of outworks; and

* It is necessary to remark, that in this investigation the works are supposed to be constructed on a horizontal plain; inequalities of ground, either on the site of a fortress or in the neighbourhood, form a separate subject. It is also to be noticed, that although the principles of Vauban's first system are explained, they are also discussed, and the opinions of approved modern engineers of experience on their properties, are given.

where advanced or detached works are thrown out, they are generally found constructed on short or contracted fronts: this has given rise to the classing of the fronts into *great, mean,* and *small:* the great fronts average from 370 yards to 500 yards; the mean from 340 yards to 370 yards; and the small from 200 yards to 340 yards.* Viewing a fortress as ground enclosed by great, mean, or small fronts, according to circumstances, the general outline is a succession of salient and re-entering angles, affording each other a mutual defence.

80. *b, The lengths of the various lines of works.* First, the reasons for fixing the lengths of mean fronts at about 360 yards: refer to fig. 2, Plate I, where all parts of

* When the student begins to examine the plans of existing fortresses he will see many illustrations of this subject: that when the fortified position is protected by a river, then two, three or four long or *great* fronts, are made, broken with occasional flanks or towers, and having heavy guns mounted on their ramparts in order to command all the ground beyond the river. In well constructed places, however, it will be observed, that the revetment walls of these great fronts are not seen from the country, as they usually have an intervening bank or glacis with a rapid slope (commonly called a *glacis coupé*). Let it be remembered, that when walls are seen they are liable to be beaten down by the fire of an enemy's artillery; and an opening or breach being made in a wall, although it cannot be stormed, is an evil, as it exposes the place within. These long fronts on sides protected by natural obstacles may average from 400 to 800 yards. Again—On the sides open to an enemy's attack, a succession of regular *mean fronts* of about 360 yards are constructed, which gives the proper length for the most formidable works capable of a protracted defence.

Moreover, in almost all fortresses points of restricted ground are found, which it is desirable to occupy, and which render *small* fronts more suitable than mean fronts for the nature of the ground.—— Thus it will be seen that the principles of the art of fortifying must always yield to localities, and the talent of the military engineer is called out in the proper application of principles to circumstances.

the enceinte are within mutual range of musketry: now the longest range is *the line of defence*, that is, the line E B, front A B; for the defenders upon the flank, H E, have to defend all the ditch before the face of the next bastion, G B, up to the salient place of arms in front of B; therefore this length, E B, ought not to exceed the effective range of the rampart muskets used upon the flank: and this is a long range; for it is 310 yards from E to B. It will soon be seen that the lengths of the faces and flanks of the bastions, as well as of the curtains, are not arbitrary, but become so dependent upon fixed principles as to force the tracing to be what it is in fig. 2, which brings the line of defence within the range of musketry; and the desired advantage of all parts of the enceinte within mutual musketry range. But if the exterior side A B were more than 370 yards, the length of the line of defence would exceed the effective range of rampart musketry, and the consequence would be, that the portion of the main-ditch about the flanked angle of the bastion would labour under the disadvantage of being undefended by musketry fire: it appears, therefore, that the exterior side of the polygon of the mean class is made as long as it can be without sacrificing a mutual musketry defence throughout the enceinte.

81. As the length of the faces of the bastion depends greatly on that of the flank and curtain, it is necessary to show on what principles the lengths of the two latter works are determined: the flank, H E, fig. 2, Plate I, being armed with musketry and artillery, requires to be long enough to defend the main-ditch by its fire; and, as at the end of a siege it has also to contend with the enemy's counterbattery established on the crest of the glacis opposite to it (at *g h*), where the assailant has a space equal to the width of the main-ditch at the salient angle (in the case

of a dry ditch, it is 30 yards) added to that of the covered-way, 10 yards, in all 40 yards; the flank H E should not be less than 40 yards long; but to give it a preponderance, it has a length of 54 yards, which enables the defenders to place more guns upon it than the enemy can in the only space (*g h*), from which he can directly counter-batter them.

82. In the front, *c d*, fig. 1, the musketry defenders on the flanks 8 and 10 have to defend the main-ditch, so that the fire from their muskets, depressed over the superior slope of their respective parapets, must meet at the bottom of the main-ditch, upon the perpendicular (*h*). Now supposing the superior slope of these parapets to have the usual depression, their prolongation should meet at the bottom of the ditch, on the line *h;* a slight consideration will show that the distance to which these flanks must be removed from each other (and this distance is the length of the curtain) must depend upon their relief. In the system now under discussion, when the relief of the enceinte is 44 feet, the length of the curtain is about 140 yards.

83. The lengths of the flanks, H E; F G, and curtain E F, fig. 2, being regulated in the manner just described, the remaining part of the lines of defence, A H and G B form the faces of bastions; and as these faces carry the most powerful batteries, it is desirable to have them as long as possible, consistent with a proper length of flank and curtain: here (fig. 2) they are about 102 yards each.

84. Thus the lengths of the exterior side, of the line of defence, of the face of the bastion, of the flanks and curtains, in a mean front, are all fixed by the rules just laid down; and a good bold relief of 44 feet, with revetments 30 feet high, can be obtained by these arrangements:

but if the length of the exterior side be less, and brought down, for example, to that of a small front of 240 yards, the consequence would be that, in maintaining a proper proportion between the lengths of the different lines of works, the relief of 44 feet must be much diminished, and reduced so that the ditches may be fully defended from the flanks. Suppose, for a moment, in a small front, a curtain of 80 yards in length, instead of 140 (as in the mean front), and the relief of the flanks to be 44 feet, it is evident that a considerable portion of the main-ditch could not be seen from these high flanks, and that the flanks must be lowered, and the bottom of the ditch raised, until the musketry fire from the flanks would meet in the middle of the main-ditch. Hence, in proportion as the exterior sides of the polygon become short, a bold relief must yield to one of less height, which of course is disadvantageous, as it gives shallower ditches, lower revetments, and less formidable works.

85. The mean fronts give good sized bastions, and a bold relief. To reduce the fronts, the bastions are contracted, and their defensive powers greatly injured. Hence small fronts should be used only on restricted ground, where mean fronts could not be traced; or in field-works, where parapets alone, without ramparts, form the defensive masses.

86. As a general rule it may be stated, that whenever the curtain would be so short that its ditch cannot be thoroughly seen from the rampart, the bastion system is inapplicable; for unless there be lower casemated flanks, the escarp would either be too low, or the ditch would not be seen; one-twelfth or one-tenth of the length of the curtain being the greatest height of escarp that the collateral defence of the bastioned system admits.

87. In the construction of Vauban's first system, it

is stated that the perpendicular is made $\frac{1}{8}$ of the exterior side in a square; $\frac{1}{7}$ in a pentagon; and $\frac{1}{6}$ in a hexagon, and all other superior polygons: the length of the perpendicular depends on the length that it is proper to give to the flanks of the bastion; for instance, in fig. 5, fronts *a d*, and *d c*, the perpendicular, *q r*, is short, or $\frac{1}{8}$ of *a d*; and in the adjoining fronts, *a b*, and *b c*, it is longer, which (under every other similar circumstance) gives short flanks in the former, and long flanks in the latter fronts. What the proper length of flank should be has been already stated (paragraph 81); the conclusion is, that the perpendicular should be long enough to give this required length of flank; and $\frac{1}{6}$ of the exterior side suffices to do so; therefore, in no case is it ever made more. It remains, however, to explain why it is made less in the cases of a construction on a square or a pentagon; now let the effect of a long perpendicular be considered (in fig. 5) as it affects the flanked angle of the bastion, and it is readily seen that, in proportion as the perpendicular lengthens, the flanked angle of the bastion becomes more acute; the angle of a square (fig. 5) is only 90° and that of a pentagon 108°; then, if to the front on these low polygons, the full perpendicular of $\frac{1}{6}$ of the exterior side were given, as in fronts *a b*, and *b c*, the interior of the bastions would become so contracted, from the acuteness of the flanked angle, that their efficiency would be greatly diminished, and the gorges nearly closed up (as in bastion Z, fig. 5): to prevent these evils, and to keep the bastions as large as the angles of the polygons will permit, the perpendicular is shortened to $\frac{1}{7}$ of the exterior side in a pentagon, and to $\frac{1}{8}$ in a square, which, in the latter case, reduces the flanks to 40 yards in length; but as the angle of the pentagon opens 18° more than that of the square, the perpendicular may be increased from $\frac{1}{8}$ to $\frac{1}{7}$ of the exterior

side, in order to obtain as long a flank as possible, without rendering the flanked angle too acute; and in the hexagon, as the angle is 120°, the perpendicular can be made $\frac{1}{8}$, or its full dimension, which never varies in higher polygons, as it gives the necessary length of flank in all ordinary cases.

88. In the low polygons of a square and pentagon, as the flanks are thus shortened, their capability to defend the main-ditch is also lessened: consequently, it has been customary to reduce the breadth of the latter to 28 and 26 yards at the flanked angle. Thus the width of the ditch and the length of the flank that defends it, operate mutually on each other; and when, from the above, or any other cause, it becomes necessary to shorten the flank that has to defend a ditch, the latter should be narrowed also; and the converse of this should likewise be kept in view, namely, that when it is necessary to widen a ditch, it should have a flank capable of defending it efficiently.

89. Although the foregoing details have been requisite in order to explain the mode of regulating the perpendicular and flanks in low polygons, yet it may be well to remark that works of a permanent character are rarely or ever constructed on a square or pentagon, except in the cases of citadels: the angles of the polygons of fortresses, of a bastion tracing, of a respectable size, being usually 130° or 150°, which is an opening sufficient to admit of large spreading powerful bastions.

90. In the tracing of the first system of Vauban, the counterscarp of the main-ditch (X w, X y, fig. 5,) is drawn from the shoulder angles of the bastion, *y*, *h*, to be tangents to the arcs before *a* and b; by this the whole flank, *v k*, can deliver its fire along the ditch to be defended; whereas, if the counterscarp were drawn parallel to the face of the

bastion, as on the front *b c* (where 1, 4, and 2, 3, are parallel to the faces of the bastions), then the ditch would be directly defended by only that portion of the flank, *m*, 1, that can look along its whole length, and it would be deprived, in a great measure, of the benefit of the remaining part, 1 *l*, that could only see it partially.

91. Thus have the leading features of the tracing of the enceinte of the first system been explained; and it now remains to show the principles upon which the outworks, covered-way, and glacis, have been traced, as far as their outline, and length of line is concerned.

92. The ravelin or demi-lune (L K M, fig. 2, Plate I.) has a capital, I K, of 100 yards; and its faces, K L, and K M, are directed to points at 10 yards from the shoulder angles (H and G) of the bastions in its rear: this makes the length of the faces of the ravelin about equal to those of the bastion; and considering that these lines have to defend and flank the ground before each other respectively, by a cross fire, and that this mutual support is of equal importance to each, they have accordingly about an equal length of rampart in their faces; the ditch of the ravelin has its counterscarp parallel to its escarp, and receives a full flanking defence from those portions of the faces of the bastions that look into it, as seen in the right front of this figure.

93. The covered-way is formed by the crest of the glacis passing around in a succession of salient and re-entering angles, all within easy musket-shot of each other; it is traced at 10 yards parallel to the counterscarp of the ditches, that the defenders may have room enough for all necessary movements within the glacis; and the places of arms give space for the assembling of considerable bodies of troops when required.

94. *The opening of the different angles of the works.*

In fig. 1, Plate I, the defenders on the faces of the bastion, *c*, being supposed to fire perpendicularly to the parapets behind which they are placed, there will be a great sectoral space before the salient angle, undefended by a direct fire, as may be seen by the lines of fire; hence the capital prolonged which leads to this angle is the least defended line, and the most proper for an assailant to select, on which to approach the work from the country; now this sectoral space, undefended by a direct fire, becomes less and less in proportion as the salient angle of the work opens, and greater as it becomes more acute; in this respect, therefore, obtuse are preferable to acute-angled works: besides which, there may be said to be two more reasons for the superiority of obtuse-angled works: 1st, they give greater interior space, and thereby admit of larger bodies of troops, and of more artillery being used in them; which, of course, increases their importance and power: the artillery too can be worked freely close up to an obtuse angle; whereas the gun-carriages on opposite faces near an acute angle will interfere with each other. 2nd, an acute angle having less solidity than an obtuse one, is sooner injured by the action of time and the weather; as well as more readily beaten down by an enemy's artillery.

95. The influence that the perpendicular exerts on the flanked angle of the bastion, has been already noticed in paragraph 87; and it will now be more clearly seen, by the above explanation, that the perpendicular must never be made so long as to choke up the valuable interior space of the bastion; but that while the proper length of flank is attended to, the opening of the angle of the bastion should be as great as circumstances will permit.

96. It has been considered as a principle that the salient angle of a work is never to be less than 60°.

97. Re-entering angles being, in most cases, angles of

defence, their opening should be regulated with reference to the best situation in which artillery and musketry can be placed for the use of these weapons. For example, take the flank, H E, fig. 2, Plate I, front A B, in the parapet of which embrasures are opened to permit the guns to defend the ditch; if the angle of defence, H E B, be a right angle, the embrasures are then cut perpendicularly through the parapet, which would not be the case if the flank stood either at a greater or less angle than 90° to the line to be defended; but the embrasures would have to be oblique to the parapet, which should be avoided, if possible, as they cut up and weaken the parapet.

98. In Vauban's first system, the angle of defence is 85°, which is sufficiently near a right angle to obtain all the advantages required by perpendicular embrasures; although in the modern system it is made exactly a right angle.

99. Those portions of the faces of the bastions that look upon and defend the ditches of the ravelins, are seldom or ever at right angles to the parts defended: the embrasures are consequently oblique to their parapets; and this construction must be adopted unhesitatingly, whenever it becomes necessary.

100. In some old fortresses and constructions, the flank of the bastion is seen to stand at an acute angle with the line of defence (as in fig. 9, Plate I, flank *b c*), having a space, *c e*, between it and the line of defence, called the *second flank* or *flank of the curtain*, intended to carry artillery in oblique embrasures, to aid in flanking the main-ditch, and contending with the opposite counterbattery. When the line of defence thus falls upon the curtain, it is called *a line of defence fichante;* but when drawn as usual to the curtain angle, it is *a line of defence rasante:* the former is evidently a defective construction, as it interferes

with all the principles already laid down ; viz., it increases the length of the line of defence, which is already too long ; it contracts the interior space of the bastion ; it obliges the embrasures to be made very obliquely, &c., without giving any compensating advantages from a weak and ill-directed additional flanking defence.

101. In examining the tracing of the covered-way which is laid out to suit a musketry fire, the faces of the re-entering places of arms stand at an angle of 100° with the adjoining branches of the covered-way ; and the reason why angles of defence for musketry are 10° more than those for cannon, is, that the latter are always regularly laid and pointed ; whereas a man with a musket, firing over a parapet in cases of darkness, fog, smoke, or confusion, is very likely to vary the inclination of his musket to the right or left, out of a line perpendicular to the parapet, which deviation may carry the fire upon his comrades in the work flanked : to prevent accidents of this kind, angles of defence for musketry are usually made with an opening of 100°.

102. In considering the general outline of the defensive masses, and in supposing that an enemy, in a steady regular siege, approaches in an equal manner, with his trenches, over the ground which he occupies, he will first arrive at the most projecting points of the covered-way ; now in fig. 2, Plate I, the salient places of arms are all nearly in the same circumference of a circle, and he can establish his batteries for counterbattering and breaching the body of the place and the ravelins at the same time ; but when the salient places of arms before the ravelins project so much beyond that of the bastion between them, that the assailant would be taken in flank and in reverse, did he attempt to lodge himself at those before the bastions, by the faces of the adjoining ravelins that completely command these

spaces: the ravelins must therefore be first taken, or their defences entirely silenced, before the bastions can be regularly attacked; a delay highly favourable to the defence: hence, great salient and deep re-entering angles tend, in general, to increase the defensive properties of works.

CHAPTER III.

USES OF THE VARIOUS WORKS IN VAUBAN'S FIRST SYSTEM OF FORTIFICATION.

103. It is now time to consider the uses of the various works of a regular front, according to Vauban's first system, the way in which they mutually flank and aid each other, and their respective properties: and, in examining each work, two things must be kept in view: the first is its intrinsic value; and the second is its relative value: the former includes the extent and power of fire that the work can bring upon the surrounding country; what obstacles it offers in itself to an enemy as to its inaccessibility of situation; its ditch; height of revetment; and its resources to prolong its defence to the utmost: the latter refers to the extent of influence that a work exerts upon the neighbouring works, or they upon it, by it capability of giving or receiving assistance.

104. Before entering upon these details, it may be well to remark, that the two weapons to be brought into full operation upon all the ground over which an enemy must advance, are musketry and artillery; for the first (whose range is the shortest), there is provided a sheltered advanced position outside of the ditches (the covered-way), from which a fire can be kept up all round the fortress: this formidable line of musketry is supported by the faces of the bastions and ravelins, or strong batteries of artillery, whose fires cross in every direction; so that every advantage to be derived from the defensive weapons is secured in the best manner by the positions of the works: and viewing

the field to be defended in this light, the most convenient mode of entering upon the merits of the works will be to begin with the covered-way, or musketry position, and then pass on to the outworks and the body of the place.

105. The covered-way being 30 feet broad, and having a parapet or glacis on its exterior, the crest of which is from 7½ to 9 feet in height, affords, in the first place (figs. 2, 3, and 4, Plate I), a secure road of communication all round the fortress, outside of the ditches: here guards and sentinels are placed, which prevent all access to the counterscarp of the ditch, to reconnoitre and sound its state or dimensions; an evil against which it is difficult to find a remedy in fortresses unprovided with a covered-way, during dark and tempestuous nights: and as the banquette is but 4½ feet lower than the crest of the glacis, a strong palisading * is placed at the foot of the interior slope of the glacis, to prevent any attempt at forcing a passage into the covered-way. From the covered-way, a close grazing fire of musketry is obtained upon the glacis and the surface of all the ground without: this is the chief musketry

* The wooden palisades used in fortresses are, in general, massive and wedge-shaped, the flat side inwards, and about nine inches broad: they are sunk two or three feet into the earth, where they are attached to a heavy beam, as well as bound at top by a ribband: they stand at nine inches asunder, so that the defenders on the banquette fire between them: they are pointed at top, and are no higher than the crest of the glacis, that they may not be seen from the country. (See fig. 6.) A second row of palisades has sometimes been placed in the centre of the terre-plein of the covered-way, as an additional obstacle to the assault of this work: and were permanent works stormed without being previously beaten to pieces by artillery, these palisades would be useful; but this is not the case; and by an enfilade fire of artillery, such feeble obstacles are swept away: moreover, a few fascines thrown in between the palisades and the interior slope of the glacis, would enable troops to pass over easily. For defensive purposes, therefore, this most expensive obstacle is of little use, when placed, as seen in fig. 6, Plate I, at the foot of the interior slope of the glacis.

position in the fortress, and being the most advanced, is defended by the weapons having the shortest range.

106. Bodies of troops can be formed in the covered-way and its places of arms, to act defensively or offensively by sorties;* although there is room in the covered-way for its defenders and all their operations, there would not be convenient space for the assembling of such bodies of men as are required for sorties, were it not for the places of arms. The re-entering places of arms also afford, by their position, a flanking fire upon the ground before the adjoining branches of the covered-way. In a fortress without a covered-way, troops for sorties or defensive purposes must be formed either within the main works when the ditch is wet, or in the ditches when they are dry: in the former case, the defenders are seen by the assailant's batteries the moment they begin to defile across the bridges; or in the latter, as they appear by successive files on the top of the counterscarp; consequently, their regular formation is broken from the first, and the power of their attack thereby greatly diminished; and as sorties issue for a specific purpose, such as to overthrow some of the enemy's works, to burn or destroy a part of their siege materials, to spike their guns, &c., the assailant has generally time to collect a force sufficient to oblige the sortie to retreat in haste: regularity cannot then be always preserved in a way that

* A sortie is an attack made by a body of troops that issue from the besieged place, upon some of the works or parties of the assailants. Well managed sorties are of much importance in prolonging the defence, either by destroying some of the enemy's works, or obliging him to proceed with greater caution, and thereby gaining *time*, which is of the utmost importance to both parties; a gain to the besieged, and a loss to the besiegers. Passages or ramps are prepared in various parts of the glacis to facilitate the egress and ingress of sorties. See the ramps on the re-entering places of arms, fig. 17; which are directed upon the neighbouring works, in order to be clear of enfilade.

is necessary to check an overpowering assailant pressing on a party that have merely narrow passages (as staircases down the counterscarp in dry ditches, or bridges in wet ditches) by which to retire: confusion and loss are then most likely to ensue; not to speak of the possibility of a bold rush being made to follow the sortie into the place.

107. Whereas, in a fortress provided with a covered-way the sorties form in the various places of arms, on the fronts required; the cavalry ready to mount, the light artillery horsed, the columns of infantry regularly formed, and the working parties paraded with their entrenching tools, &c., to demolish the enemy's breast-work or parapets: while the crest of the glacis is lined in every direction with light artillery and musketry: the sortie issues by many passages cut through the glacis (either so obliquely or curved, that the enemy cannot enfilade them), and immediately proceed to the attack: the work being accomplished, the party retires in like manner, protected by the near fire of their comrades within the glacis, where a secure position is at once afforded them to face about and repel all further attempts.

108. The crest of the glacis being on an average about 8 feet above the level of the ground, the scarp revetments of the main works in its rear can thus be made 8 feet higher than would be possible if there were no glacis; for it has been already shown how necessary it is to hide all the revetments from the fire of distant batteries: thus a most important result is obtained by the covered-way and glacis, in the increased height of the scarp revetment.

109. The exterior part of the fortification, namely the glacis, presents to an enemy an indestructible bank (for the slope is scarcely two inches to a yard in length), exposing its whole surface and all beyond it to the fire of works in the rear: up this glacis the assailant must work, and must reach its crest ere he can see the revetments of the place:

here he is in a position exposed to the fire of all the remaining defences; and by its elevation, greatly interfering with, and masking the effects of, his own batteries in the rear.

110. An enemy cannot descend to establish his batteries in the covered-way, for it is only 30 feet broad; which, although quite wide enough for all the necessary movements of the defenders, is too narrow for the assailant to construct a parapet next to the counterscarp, and to work his guns behind it; for this would require a space of at least 44 feet: and as the crest of the glacis is but 30 feet from the counterscarp, there would remain 14 feet of glacis to cut away from the crest: a proceeding too long and too laborious to be contemplated in common cases. For the defenders, the covered-way is only a musketry position, aided occasionally with light artillery in the places of arms; but the assailant would fain make it an *emplacement* for his breaching batteries, if it were wide enough for the purpose. In order to show how the width of the covered-way sometimes interferes with the assailant's breaching batteries, let the diagram in fig. 10 *a*, Plate I, represent the section of a ditch of 100 feet wide, with the neighbouring scarp, counterscarp, and covered-way: let *a* be the besieger's breaching battery, if the sole of the embrasure be sloped down so as to enable the breaching gun to clear the top of the counterscarp revetment; this sloping line, *a c*, produced, will show how far down the revetment the shot will strike: in this case $a\,b : b\,c :: a\,d : d\,e$, or $52 : 8 :: 152 : 23\frac{5}{8}$; therefore, the shot from the gun, *a*, will strike the scarp revetment (which is 30 feet high) between 6 and 7 feet from its base; and which, in this case, would be sufficient to effect a practicable breach: but it is evident that by a change in some of the foregoing terms of the proportion, a result could easily be produced which would screen the lower part of the scarp

vetment of the curtain and flanks of the bastions from the view of the enemy's batteries established on the crest of the glacis; or subsequently in the ravelin after its fall: therefore, a breach fit to assault cannot be made in these parts of the enceinte, and the revetment of the face of the bastion alone is sufficiently exposed to have a practicable breach made in it: thus, then, the enemy must assault that portion of the enceinte behind which the defenders have ample space for making the best defence possible. The relief of the tenaille is usually 23 or 24 feet: hence an enemy's battery, at *h' g'*, (fig. 2, Plate I) on the crest of the glacis, could see over the tenaille, and beat down the upper part of the revetment of the flank *m*, as well as part of its parapet; but this would not be sufficient to form an assailable breach: for this purpose it is necessary to see to the bottom, or nearly to the bottom of the wall. Again, the mass of the tenaille is no less useful in hiding from the enemy's establishment on the covered-way, the opening or door of a vaulted passage or postern of masonry, which postern is indicated by the dotted lines in the centre of the curtain on the right front of fig. 2, Plate I, that communicates from the interior slope of the rampart in the centre of the curtain, to the main-ditch: a postern is also pierced through the tenaille itself (figs. 2 and 4), and a protected passage, the caponier, then leads to the gorge of the ravelin: thus a communication is kept up between the enceinte and the ravelin: a matter of the first importance in giving vigour to the defence of this latter work. Now, if there were no tenaille, as on the front, *c d*, fig. 1, the batteries of attack, on the crest of the glacis (at 3), would completely command the mouth of the postern, and prevent any egress or ingress by it, the only passage from, and to, the interior of the place; a result that would be ruinous to the active defence of the outworks, and which would entirely preclude

the formation of troops in the rear of the tenaille, for offensive purposes, at the latter part of the siege. Suppose that on the front, *a r*, fig. 1, Plate I, the main-ditch to be filled with water, which, of course, passes round the flanks and the rear of the tenaille ; and as the relief of the tenaille is generally from 23 to 28 feet, its crest would be from 15 feet to 20 feet above the level of the water, there would, therefore, be a space of dead ground, or rather of dead water, before the tenaille; this is not, however, of great consequence, as no force of the enemy could get there without being seen on their way ; and no object is to be gained by getting there, for possession of the tenaille would be of no use ; nor could this isolated work be kept under the tremendous fire of the flanks and curtain. In a dry ditch this dead ground is rectified by a caponier. The ditch in rear of the tenaille must always be 30 feet wide. Tenailles are differently traced in other systems.

118. A caponier is placed in a dry ditch, for the purposes named in article 48 : for instance, in fig. 2, Plate I, there is a single caponier, *c*, in the bottom of the ditch of the ravelin, to cover the defenders passing from the end of the wall of the ravelin to the staircase in the re-entering place of arms, and there is a double caponier at the bottom of the main-ditch, from the mouth of the postern in the tenaille to the staircase at the gorge of the ravelin. Caponiers are placed wherever they may be required. When a cunette is used, it is flanked by a caponier. Fig. 7, Plate I, is the profile of a double caponier, such as shown on the right front of fig. 2.

119. We now come to consider the uses and value of the various parts of the enceinte: the reader is referred to paragraphs 80, 81, 82, 83, for the principles of their construction, and for some of their uses ; from which it may be gathered that the bastions are the most important parts

of the enceinte, from their projection, position, and interior space. The whole of this first enclosure, being the last permanent obstacle the enemy has to overcome, it is consequently the most formidable, having a broad ditch before it, with scarp revetments from 30 feet to 35 feet in height; massive ramparts and parapets carrying the heaviest artillery, the various lines of which mutually flank each other, and by their height, overlook all the works before them. In fig. I, Plate I, in the fronts *d a*, *a r*, it may be seen, by the position of the faces of the bastions, that they fully flank by their fire all the ground before the faces of the ravelins, and all the approaches by their capitals to their flanked angles, or weak points: the ditches of the ravelins are also defended by the fire of those portions of the faces of the bastions that look upon them; and these must be silenced ere the enemy can pass the ditches thus flanked to assault the ravelin. Each flank of a bastion can carry batteries or five or six pieces of artillery to defend the main-ditch; and as it has been already shown that the faces of the bastions are the only parts of the enceinte in which the assailant can make practicable breaches, it is quite necessary that the ditches, by which these breaches can be reached, should be fully swept by the fire of the flanks; now, in a regular attack, the passage of the main-ditch cannot be effected under the fire of so strong a battery, which has to be silenced before the attempt be made. The curtain may be said to have more a passive than an active defence; it closes in the body of the place by joining the bastions to each other, and it overlooks the works before it; into which it can pour a strong fire after their fall into the hands of the assailant; as it has only a command of observation over the ravelin, its embrasures must be oblique to fire into the covered-way, or upon the country beyond it. Thus, in the enceinte, the faces of the

bastions may be said to have the most active duties to perform: the flanks are for a specific object, viz., the defence of the main-ditch; and the curtain is nearly a passive barrier till the end of the siege, when its fire tells strongly on the works before it.

120. *Vauban's orillon and retired flank.* See fig. 10. The original flank, *a b*, is divided into three equal parts, one-third, *a c*, is occupied by the orillon; the centre of this curve is obtained by bisecting *a c*, by the line *e f*, and raising a perpendicular at *a*, to the face of the bastion. The retired flank is described thus: draw the line *h g*, parallel to *a b*, at 10 yards distance; (*c h* and *b g* are both directed from the flanked angle of the next bastion); on this line *h g*, construct an equilateral triangle; and from *k*, as a centre, describe the arc *h g*, for the retired flank, and *c b*, concentric from the point *k*, for a lower flank: the embrasures in this lower flank, shown by dotted lines, would probably be 14 feet below those in the upper flank: and thus a double tier of guns would be obtained to defend the main-ditch—this construction, however, forbids the use of the tenaille; it must be suppressed, in order to allow these two batteries of guns to sweep the main-ditch: and it has already been shown, that the uses of the tenaille are much too important to dispense with its construction in our ordinary bastioned front. Towards the conclusion of the siege, the enemy's counterbattery (finally constructed in the space *g h*, fig. 2,) prevails in silencing the guns on the flank H E: but Vauban conceived that with the orillon, the last gun, in the retired flank at *h*, fig. 10, might be so concealed from the view of the counterbattery, that it could not be silenced, because the line *h c*, prolonged, falls on the salient point of the next bastion: this is not only a doubtful case, but this single gun, at *h*, could certainly be silenced by vertical fire, or even by enfilade fire, from some

portions of the offensive works. It is also to be remarked, that the construction of retired flanks in a bastion greatly contracts the interior space, which should be avoided.—— On the whole, the orillon and retired flank has been discarded in modern fortresses.

CHAPTER IV.

ON RELIEF AND COMMAND. ON DITCHES—THEIR CAPACITY —WET AND DRY. MEANS OF COMMUNICATING BETWEEN THE INTERIOR OF THE FORTRESS, AND THE COUNTRY, AND BETWEEN THE DIFFERENT WORKS. ON PLAN DRAWING.

121. From what has been said, in Chapter III, it follows, that however important it may be to dispose the tracing of the works of a fortification, so that their reciprocal defence may not interfere with their general effect upon the country; it is of no less importance to fix the relief which determines the proper elevations of the works, respectively, so as to ensure the full effect of their fire for all the purposes desired. The relief is generally determined by means of profiles; and it is said that a place is well *profiled*, when the works cover and defend each other, without injury to their particular command over the country. In considering this subject, the pupil is reminded that the works are still supposed to be constructed on a horizontal plane: the intricacies of construction, in cases of irregular sites, or the neighbourhood of hills, are explained elsewhere.

122. In profiling the works of a fortress, the following principles should be kept in view:——1st. That all parts of the surrounding country, within the range of the artillery and musketry of the defences, should be seen and exposed to their fire.——2nd. That an enemy from without should not be able to see any part of the interior of the

works.——3rd. That no part of the revetments should be seen by an enemy till he has worked up to the crest of the glacis.——4th. That all the works progressively increase in height as they approach the body of the place. The first principle has been established, in order that an enemy may not get cover from natural obstacles within range of the defensive weapons; to oblige him to begin the works for the siege at a considerable distance; and that he may be fully exposed to the fire of the place as he progresses towards it. The second principle shows that an enemy must not have it in his power, while yet at a distance, to drive the defenders from their works. (Its application to works within the range of heights which an enemy can possess, forms the subject of defilading.) The third principle is to oblige the enemy to bring his battering train of guns to the crest of the glacis; as, till then, he cannot see the scarp revetments to form breaches fit for assault. The fourth shows, that when an enemy gets possession of the works in succession, beginning with the outermost and lowest, those that remain, being more elevated, can bring a fire upon the captured works; either to drive an enemy out of, or to disturb his lodgment in them. Moreover, that the low and high works may fire together, and that the most formidable works should be the last to be taken. The tenaille is an exception to this rule, for reasons stated in paragraph 117. In the application of these leading principles, they must be subservient to the promotion of the great objects of the tracing and the uses of the works, as stated in Chapters II and III; and also to ensure the full effect of the defensive weapons.

123. In the first place, in order to determine the proper command for the enceinte over the country, let S, fig. 2, Plate I, be about the position of the enemy's third parallel (or his last trench ere he begins to push his works up

to the glacis); and let a section on the line, *n r* S, of fig. 2, be represented by fig. 3; the horizontal distances in both figures being represented by the same letters, *n r* S: it is required to know how high the gun at *n*, fig. 2, should be in embrasure, to permit it to fire upon the enemy's trenches at S, without injury to the musketry defenders on the covered-way at *r*. The horizontal distances in the two figs. 2 and 3, are as follows: in fig. 2, S *r*=300 feet (in fig. 3, S *g*=300); S *n*=450 feet: the crest of the glacis in fig. 3, is 8 feet high (that is *g r*=8 feet); and if the line, *n e* S, be supposed to represent the track of a shot fired from the gun, *n*, at the trench, S, and to pass clear of the crest, *r*, of the glacis by 4 feet; then *g e*=12 feet. Now there are two similar right-angled triangles in fig. 3, viz., S *g e* and S *x n*, of which the two bases and one perpendicular are given, to find the remaining perpendicular *x n*. S*g*: S *x* :: *g e*: *x n*; or 300 feet: 450 feet :: 12 feet: 18 feet, but a gun in embrasure is 4 feet below the crest; therefore, to obtain the full command of the work, 4 feet must be added to the 18 feet found, which gives 22 feet for the command of the enceinte over the country; and 14 feet for its command over the crest of the glacis. Thus the command of the enceinte is determined; but it is plain that, if the tracing varies from that here laid down, the result of the proportion will do so likewise: if, for instance, the ditch be wider than 30 yards, the base of the triangle, S *x n*, fig. 3, will be greater, which will augment the second term of the proportion and produce a greater result: or, in other words, the enceinte will be higher. A covered-way wider than 30 feet would also increase the height of the enceinte; and if the crest of the glacis were made higher than here stated, so as to increase the third term of the proportion, the result would still be to increase the height of the enceinte. A tracing that would produce the converse of

the above, would of course, permit the enceinte to be made lower. It is now easily seen why the ravelin can be made lower than the enceinte, and still maintain a sufficient height over the crest of the glacis to act upon the enemy's works ; since, by the narrowness of the ditch of the ravelin, the distance between its crest and that of the glacis is 30 or 40 feet less than between the crests of the faces of the bastion and glacis ; for the command of the ravelin is determined in a like manner to that detailed above for the enceinte ; and if the artillery on the faces of the bastions and ravelins can thus clear the crest of the glacis when their fire is directed upon the nearest trenches, they can of course, act upon all beyond them : and, in proportion as the object fired at is distant, the track of the shot will be more and more above the crest of the glacis.

124. Although the foregoing arrangement is drawn from Vauban's works, and the opinions of those who have followed him, yet it is not to be expected that the musketry defenders can man the whole of the banquette of the covered-way, and be in security from the shot of their own guns, that would absolutely graze their heads when firing at the enemy's third parallel. To permit both parties to act freely by their fire upon the foot of the glacis, the crest of the advanced work should be at least 8 feet below the track of the shot flying over it, that the defenders behind it may be quite safe ; if this were carried into effect, it would alter the third term of the proportion, paragraph 123, to 16 feet ; and produce the great remblai of 28½ feet for the command of the enceinte over the country ; a result, too, that would greatly interfere with many of the principles of tracing already detailed (as for example, with that of the length of the curtain at paragraph 82). Nevertheless, if such portions of the banquette of the covered-way as do not immediately lie under the range of the artillery on the

main works (such as the places of arms) be furnished with a musketry fire, and if the service of the guns be carefully carried on, these two arms can act thus partially and efficiently together upon all the enemy's approaches. The action of the guns in barbette never interferes with the musketry from the glacis. It would therefore appear, that as the artillery and musketry cannot always act simultaneously, and as, on some occasions, it becomes necessary for the musketry to descend from their banquettes and lie down in the covered-way, that it is possible to do with such a height of enceinte as will permit the guns in embrasure just to clear the top of the palisades of the covered-way, when the shot is directed at the enemy's third parallel: and some writers recommend this fire as being more destructive, as grazing along the surface of the ground; while shot fired from higher works, being more plunging, bury themselves in the spot they strike, and do no further damage: advocates for the *grazing fire* would limit the command of the enceinte to 17 feet over the country, and 9 or 10 feet over the crest of the glacis. More generally, however, a *plunging fire* is preferred: since a shot fired upon the enemy's trenches from a height, cuts more deeply through the crests of his parapets, and obliges him to heighten them or deepen his trenches in the rear, in order to obtain sufficient cover; the loss and delay of which is of more consequence to the defenders than the imagined destruction of a grazing fire from a work a few feet lower; besides, low works are more easily enfiladed than high ones; those who prefer the latter recommend the crest of the enceinte to be made 25 feet above the country. This would, however, greatly increase the remblai, and interfere with the principles of tracing already laid down, without giving a corresponding advantage for such sacrifices. A medium, therefore, of 22 feet is about the standard followed by Vauban and other engineers of experience, as

it permits both the musketry on the covered-way and artillery batteries in its rear to act together in a great measure. Circumstances, however, may perfectly justify a departure from this rule: for example, a command of 17 feet for the enceinte over the country, for a small front of 240 yards, would be much more suitable, and harmonize much more with the tracing than a command of 22 feet.

125. In article 122, it is said that the tenaille is an exception to the fourth principle of relief: that is, all the works of a regular front progressively increase in height, as they approach the enceinte, except the tenaille. The reader must here refer to paragraph 117, and be acquainted with the uses of the tenaille, ere he can pursue the following principle relating to its relief. When the enemy gains the crest of the glacis, and there establishes his counter and breaching batteries, he will have one on the space $q\,q'$, fig. 2, Plate I, which will command the ditch of the ravelin immediately before it; and through which opening he can form a breach in the face of the bastion near the shoulder angle at $k\ k'$; and, as there is no other part of the enceinte, save the faces of the bastions, that can have practicable breaches made in them; that made at $k\ k'$ will be the nearest to the flank, m, that can be formed; and if the battery on m can bear on the bottom of the ditch before k, it will, of course, command the main-ditch all the way up, from k to the rounding of the counterscarp. Now the relief of the tenaille must not be permitted to interfere with this fire from the flank; in other words, a shot fired from a gun (m) in embrasure, must clear the crest of the tenaille by four feet. In this tracing (fig. 2), the horizontal distance, $k\,m=542$ feet, and $k\,l=378$ feet: the vertical height of a gun, at m, above the level of the main-ditch is 40 feet (for here the crest of the enceinte is 22 feet above, and the bottom of the ditch is 22 feet below, the ground-line, as

seen in fig. 4, making a total relief of 44 feet for the enceinte ; from which take 4 feet for the axis of the gun in embrasure at *m*, below the crest). Let these distances be laid down as in fig. 13, in the right-angled similar triangles, *k m m'*, and *k l l'* ; *m m'* being the vertical height of 40 feet, and the horizontal distances agreeing with the corresponding letters in fig, 2 ; the line, *m' k*, will represent the flight of a shot fired from the gun, *m'*, to the bottom of the ditch, *k* ; and *l'* is the point in this flight directly over the tenaille : it is then required to find the height, *l l'*, and from it to deduct 4 feet, for the relief of the tenaille at this spot ; this is done by the following proportion : *k m : k l : : m m' : l l'* ; or 542 : 378 : : 40 : 28—4=24 feet nearly, or *l x*, the relief of the tenaille. By considering the position of the flank and of the tenaille, it is seen, by fig. 2, that the crest of the latter is continually receding from that of the former, on the line, *m k;* therefore, (supposing the flank *m* to be armed with six guns), although the three guns from *m* to the shoulder angle have a full clear view of the bottom of the ditch at *k k'*, the other three guns, from *m* to the curtain angle, are masked, to a certain degree, by the left face of the tenaille ; and it is only by directing their fire over its right face, that they can strike the bottom of the main-ditch, near the required part ; nevertheless, when it is considered that the breach is a slope of rubbish from the bottom of the ditch upwards ; and that guns on the flank, *m*, can be depressed lower than is illustrated by fig. 13, so as to graze the crest of the tenaille (as the line, *m' x*, indicates), it shows that this mode of determining the relief of the tenaille ensures the full action of the flank of the bastion upon the main-ditch before the face of the next bastion.

126. In paragraph 117, it is noticed, that, in wet ditches, there would be a dead space before the angle of the te-

naille ; now, by the foregoing observations, it would appear that the two or three guns near the shoulder of the flank, *m*, fig. 2, would be enabled to plunge their fire into nearly the whole of this space ; and both flanks thus acting, the undefended part would be reduced to a very small space. Yet, although the relief of the tenaille is fixed at 24 feet, (when the tracing is as in fig. 2, and the relief of the enceinte is 44 feet ;) a different tracing or relief would immediately alter the proportions, and produce a different result. In the relief is included the depth of the ditch ; and every change in it would affect the height, *m m'*, of fig. 13 ; as would also a ditch permanently filled with water : for example—if the ditch, in fig. 2, had 8 feet depth of water, its surface would be more exposed to the fire of the guns upon the flank, *m*, than the bottom of the same ditch would be when drained of water ; in such a case, the horizontal distances, in fig. 13, would still remain the same, but the vertical height, *m m'*, would be less by 8 feet ; the proportion would then be as, 542 : 378 : : 32 : 22—4=18 feet, for the height of the tenaille above the surface of the water, and if to this be added the 8 feet below the water-line, there will be a total relief of 26 feet for the tenaille, which exceeds that found in the same ditch, when dry, by 2 feet. Hence, shallow or wet ditches allow the tenaille to be higher, above the ground-line, than deep and dry ditches.

127. *On ditches.* When the soil in which the ditches are excavated is of a nature that is suited for the construction of the ramparts and parapets, the general capacity of the ditches will then depend upon the quantity of earth required for these defensive masses. And, in the first instance, to suppose that the soil is of this nature, will be the simplest way of estimating the dimensions proper for ditches.

128. The quantity of earth required can be procured

either by making the ditches broad and shallow, or narrow and deep; and to examine how far these two modes affect the principles of relief and tracing, already laid down, let it be supposed that the main-ditch, in fig. 2, Plate I, instead of being of the width and depth already named, furnished the same quantity of soil by being made broader and shallower; for instance, let the breadth be increased at the rounding of the counterscarp to 40 yards: and for the soil thus obtained, let there be a corresponding lessening of the depth; suppose it to be 18 instead of 22 feet deep. The first effect of this would be to lessen the height of the revetments by 4 feet; which would make the scarp walls of the enceinte and ravelin 26 instead of 30 feet high; and therefore, render them more liable to be carried by escalade in an assault. The second effect would be to render the enemy's lodgment on the crest of the glacis more formidable, as it would give him more space ($g\ h$, and $g'\ h'$ fig. 2,) for the establishment of his counterbatteries against the opposite flanks of the bastions; and render it more easy for him to overpower them. The third effect is to remove the crest of the glacis farther from the crest of the enceinte, and thereby (according to the principle of relief laid down in paragraph 123) to cause an increased command for the latter over the former, which in the construction would entail the expenditure of time, soil, and labour. These three effects are so many arguments against widening the ditch, and giving it less depth; besides which, shallow ditches ensure to the enemy's breaching batteries on the crest of the glacis, a full view of the whole scarp revetment, even to its foot; and lastly, if the main-ditch be of a less depth than 22 feet below the plane of site, there will be no necessity for making the curtain 140 yards long: and if shortened to the length required for the proper defence of the ditch, the flanks of the bastions (al-

ready too short for a wide ditch) become still shorter ; the faces of the bastions longer; and a total change effected in the tracing, to its great prejudice. One advantage alone is gained by widening the ditch, which is, that it increases the labour of one of the enemy's last operations in the attack, that of constructing a passage across it, which, in wet ditches, is an arduous and toilsome work : and hence it is that it is recommended to make wet wider than dry ditches.

129. Now the effect of a contrary proceeding, viz., that of obtaining the earth required, by making the ditches deeper and narrower than the dimensions hitherto laid down, is also to interfere with the principles of construction detailed in the foregoing parts of this work ; although the evils resulting from it (when not carried too far) are not so prejudicial to the defence, as in the case of broad and shallow ditches : for the effects are, of course, converse : in the first place, the revetments are heightened, and thereby rendered more difficult of escalade : the space on the crest of the glacis for the establishment of the enemy's counterbatteries against the flanks of the bastions, is more restricted : and it may be even necessary for him to descend into the covered-way and to construct his breaching batteries there, that he may see the revetments sufficiently low down to make a breach, as from the crest of the glacis he may not be able to do so : this will greatly augment his labour and occupy his time ; but although these are positive advantages arising from deepening the ditch, yet, in order that a deep main-ditch may be properly flanked, the curtain must be increased in length, which immediately affects the flanks, making them longer, and shortening the faces of the bastions ; this would entirely interfere with the tracing which, as has been shown, is most suited to the enceinte ; it would affect the shape of the ravelin, by making it spread more to the rear ; and in the relief, it would permit the command of the en-

ceinte and of the ravelin over the covered-way to be less: the relief of the tenaille is always affected by the depth of the ditch (paragraph 128): and lastly, in a narrow ditch the rubbish that falls from the formation of a breach would stretch across the bottom of it, and form a rough parapet in a dry ditch, or a rough causeway in a wet ditch; which in either case would greatly assist the besieger: to prevent this last evil, it is a rule that the ditch is always to have a width of at least once and a half the total height or relief of its work.

130. From the above sketch of the effects of altering the dimensions of ditches on a regular front, it appears that less evil would accrue to the defences by ditches being made rather deep and narrow than the reverse: but although this applies in common cases, it may be impossible to adhere to the desired medium between them, under the circumstances of rocky, swampy, or sandy soils; the materials excavated from which are not only unfit to enter into the construction of ramparts and parapets, but the ground itself requires great labour and expense to work in. Yet, however bad the soil may be, it is consolidated by a careful construction, and by time, while the light parapets and trenches of the besieger are worked under every disadvantage in such soil, and exposed to a fire while under construction. It is not here meant, that deep broad ditches are not more formidable obstacles for the assailant to overcome than the moderate ones spoken of in a regular front on a horizontal plain; but however deep and broad a ditch may be, it should be perfectly flanked, that the enemy's miner may not be able to attach himself to the walls, and destroy them by the explosion of mines; and, in no case, should the general good arrangement of the works be sacrificed to obtain a formidable ditch.

131. The next point to enter upon is, the kind of ditch

best suited for defence: that is, the consideration of wet ditches; dry ditches; or those that, by well-managed currents of water, can be made wet or dry at pleasure. If a ditch be permanently wet, it can only be crossed by bridges or boats; and so long as an enemy is at a distance, the communication between the place and the outworks can be kept up with tolerable ease and security; but from the moment that he establishes himself on the crest of the glacis, his batteries will command all the ditches; the bridges are swept away by his fire; and every attempt to cross must be under his view by day, or within his hearing by night; thus the defenders are deprived of the means of succouring the outworks in the time of need; and the consequent effects upon their defence are so prejudicial, that some engineers object to permanently wet ditches, except in swampy ground (where it cannot be well avoided), or when a fortress, from having low or defective revetments, which may offer an inducement to the enterprise of an enemy to attempt to carry it by surprise and escalade; more particularly if the garrison be inefficient, either from the quality or number of the troops; in this case, a wet ditch serves to secure the place from a coup-de-main. Wet ditches also augment the labour of the besiegers in constructing bridges or causeways across them, at the end of the siege, to connect the breaches to the counterscarps. If the ditches of a fortress be permanently dry, then the important object of a safe communication between the enceinte and the outworks is secured by means of posterns and caponiers; which gives vigour to the defence, and keeps the enemy from the main enclosure as long as possible. Mining operations also can be carried on in dry ditches to augment the duration of a siege. Ditches are sometimes made upon different levels, as in the Modern System.

132. If the situation of the fortress admits of the

ditches being filled with water at pleasure, there is no doubt that a preference should be given to thus combining the advantages of the wet and dry ditch; and from what has been said (in paragraph 77) on the general site of fortresses, it is not uncommon to be able to secure these objects; since the flowing and ebbing of the tide on the sea-coast, or its influence on the rivers on which fortifications are so generally constructed, renders such a means of defence available. The batardeaux (paragraph 50) should be constructed in situations where the enemy's batteries cannot reach them; for, if exposed to his fire, these barriers and their sluices would be destroyed, and the ditches made either permanently wet; or, if affected by the tide, the enemy would always know when they were passable. But if the batardeaux and sluices remain uninjured, the besieged may keep the ditches dry as long as the outworks can be defended, and inundate them to increase the difficulty of the enemy's work in effecting a passage across; which work may be swept away, or retarded, by well-managed currents of water.

133. *Plans and profiles.* It is evident from what has been said that in representing the works of a fortress, a plan is necessary in order to show the tracing and disposition of the works; and also a set of profiles to exhibit the different heights and depths above and below the ground line: the reader is now familiar with these, and the necessity of having such drawings.

134. It need scarcely be observed that a mass of earth, such, for instance, as we have in fig. 6, which represents a plan and section of a parapet or traverse in the covered-way, must have a support at each end: if it were not so, the ends would assume large slopes, having bases equal to their heights; and then the traverse, instead of having a crest about 26 feet long, would be only 15 feet;

so that the number of men placed on its banquette would be diminished from 9 men to 5 men, and thus the quantity of fire reduced considerably: besides which, a set of traverses with crests across the covered-way of only 15 feet long would not protect it from an enemy's enfilading fire so well as parapets having crests of 26 feet long. Hence the necessity of supporting the ends of these traverses; and indeed of all the ramparts and parapets either by walls or other means, such as sod or turf revetments used in field-works. Take for example the traverse in fig. 6; one end is supported by the counterscarp revetment wall, which is built up in continuation of its slope (which equals one-fifth of its height); and the other end is supported by a turf revetment with a base of one-fourth of its height. Then as the height of the crest is 8 feet; $\frac{8}{5} = 1\frac{3}{5}$, and $\frac{8}{4} = 2$; making together $3\frac{3}{5}$ feet, or the quantity to be deducted from the crest, which would leave $26\frac{2}{5}$ feet—a good useful, substantial traverse, giving a good fire and protecting all behind it on the terre-plein. The plan in fig. 6 shows the details which are applicable to each traverse in fig. 2: the palisades are shown in plan and elevation, and also in section: these palisades are also placed on the banquette of each traverse: and being continued across the opening or passage between the end of the traverse and the glacis, forms a barrier-gate there. The lower part of fig. 6 exhibits an elevation of the counterscarp revetment wall, built up, in one part, in continuation of its slope, in order to support the end of the traverse; also the banquette and palisades of the glacis in elevation; the part *a* is left without palisades, to show the interior slope of the glacis and its banquette.——The ends of the ramparts and parapets on the faces of the ravelin and tenaille are sustained in like manner by the revetment walls being built up to support them; this arrangement may be fully understood by examining figs. 11 and 12; sections

of these works are given in the figures, and if the heights in each case be divided by 5 (the slope of the revetment being equal to one-fifth of its height) the results will be the dimensions required in order to fix the profiles for the extremities of these works. Sometimes, even in sloping revetment walls, the extremities of the ramparts, parapets, and traverses are finished by perpendicular walls. It is customary in drawing plans on a small scale, to suppress the slopes that have very small bases: such as the interior slopes of parapets, the ends of traverses. The expense and labour of renewing the field revetments for the interior slopes of parapets, and to the cheeks of the embrasures, is very small: as they are not formed till a siege is apprehended, the interior slopes and banquettes remaining in a rough state; and the only embrasures permanently open are those intended for the defence of ditches.

135. Staircases, about 6 feet wide, are made in the revetment walls at the re-entering places of arms; at the gorges of the ravelins and tenailles; also in a curved outline at the salient places of arms. Their length in the tracing is usually from 24 to 36 feet, according to the height of the wall, so that the ascent may not be too steep.

136. Ramps are gentle slopes of earth, constructed along the interior slopes of ramparts, to facilitate the passage of artillery, &c., from the interior to the terre-plein of a work. They vary from 20 to 36 yards in length, and from 4 to 6 yards in width: the usual slope is about $1\frac{1}{2}''$ to 1 yard.

137. *Communications.* The communications between the interior of the place and the country; between the various works; and those to facilitate the passage of artillery, &c., from one part to another, may be divided into—

1. Gateways.
2. Bridges.
3. Posterns.
4. Caponiers.
5. Staircases.
6. Ramps.

Of these, the two first may be considered as especially made for the convenience and use of the inhabitants in their intercourse with the country: and the four last more particularly for the use of the garrison.

138. Of the former, there should be as few as possible, since they entail extra duties on the garrison, requiring constant watching and repair. In places of a small size, and, if possible, in every place, two main passages should be made to suffice; for instance, in fig. 1, Plate I, the opposite fronts, *c b* and *a r*, have regular bridges of timber across the ditches; with passages through the ramparts and glacis, which lead to the main roads without: in the centre of the curtain, the rampart has a large vaulted passage, supported on each side by masonry, to form a road sufficiently wide for the passage of carriages, waggons, &c.; that is, from 18 to 24 feet wide and 12 feet high: this passes in front, *a r*, underneath an archway in the scarp revetment, and leads over a bridge, on the same level (that is, the plane of site) to the tenaille: the passage is continued through the parapet of the tenaille, then by a bridge over the main-ditch to the gorge of the ravelin; in like manner, it proceeds through the ravelin, its rampart, and across its ditch by a bridge, (all on the plane of site,) to the covered-way: a winding road is cut through the glacis (to prevent its being enfiladed), which leads to the main roads without. Here it may be observed, that this road, and the bridges it crosses, are fully defended; the main bridge leading from the body of the place to the ravelin is placed between the batteries on the flanks of the two adjoining bastions; as well as exposed to the fire of the tenaille and curtain: the continuation of the road through

the ravelin and across the bridge of its ditch, can be both enfiladed and flanked from the different parts of the enceinte that command it: in short, this road of communication is better protected in this situation than it could be if placed in any other part of the works. The bridges are always broken by drawbridges, which can be raised on a moment of emergency; and are usually drawn up every night, by order of the governor of the place: guards are necessary in the covered-way, ravelin, and curtain, to protect and watch the bridges; and every precaution is constantly used to prevent an enemy getting any access to these passages, either by force or stratagem.——It has been usual to have high ornamented gateways leading to the bridges in the scarp revetments through which the road leads; but they are disapproved of, for being higher than the revetments, their masonry is seen above the crest of the glacis, and they thus point out to an enemy the exact position of the bridges, and assist him in destroying the communications, from his distant batteries, by shells; besides which, these great gateways occupy 30 or 40 feet in the length of the revetment, and prevent that portion of the parapet from furnishing any fire.

139. *Posterns* are vaulted passages of masonry constructed underneath the mass of the rampart, to communicate from the interior of a work into the ditch before it, as at *p p*, in fig. 4, Plate I: in a dry ditch, the door at the mouth of the postern is about 6 feet from the level of the ditch, and the defenders pass up and down by temporary wooden steps, which are removed at pleasure; so that, if an enemy gets into the ditch, and is so powerful that the defenders must retire by the posterns, the wooden steps can be drawn into the mouth of the postern, and the door shut, which, being loop-holed, permits a fire of musketry to be brought upon the assailants. Posterns are usually from 5 to

9 feet wide, and from 6 to 7 feet high at the crown of the arch; they are closed at each extremity by doors, within which are recesses of masonry for stores, &c.: although posterns are only intended as secure covered passages for men to pass from the inside to the outside of a work, yet, when 9 feet wide, they will admit of light artillery being taken through them and passed into the ditch on inclined planks; and, even when narrower, guns and their carriages can be passed through when taken to pieces. In wet ditches, the posterns lead from the interior of the rampart to the level of the bridge that crosses the ditch; or, if the ditch be crossed by boats, to the level of the water. Posterns are made on the first construction of the fortress, wherever they may be required; the interior earthen slope of the rampart is suppressed, and masonry walls support the sides of the passage leading into the postern; the vault of which passes through the whole thickness of the rampart, as seen in fig. 4; the masonry being, of course, made strong enough to resist the pressure that it has to support both laterally and vertically. In a regular front, as fig. 2, Plate I, front B N, the postern in the centre of the curtain is indicated by the dotted cross lines, issuing out into the main-ditch, behind the tenaille, where the defenders are in perfect security: they proceed through the mass of the tenaille by the postern (shown in its centre by the dotted cross lines), and then pass through the main-ditch covered by the caponier; either to ascend by the staircases at the gorge of the ravelin; or to proceed by the passages along the foot of the demi-gorge walls of the ravelin to the staircases leading into the re-entering places of arms. It was through passages of this kind that sallies issued in the old fortifications, which obtained for them the name of *sally-ports*, by which they are still sometimes called.

140. On staircases, very little need now be said, as

their situation and dimensions are laid down in paragraph 135: they should always have a sufficient slope to make it easy to pass up and down quickly. Staircases are, in many cases, carried down within 6 feet of the bottom of the ditch, and temporary wooden steps are used to reach the bottom: these are removed at pleasure, to render it difficult for an enemy to enter a work by the gorge should he succeed in getting into the ditch. Staircases are objected to from the possibility of their being greatly injured or destroyed during a siege by shells falling and bursting upon them; which likewise causes many splinters; and it is difficult to repair or restore the communication during the arduous occupations of a siege.

141. Ramps, being long, broad earthen slopes, as described in paragraph 136, are most useful and convenient communications; easily repaired if injured by shells during a siege. As ramps in the interior slopes of ramparts are for the use of artillery, &c., they should be sufficiently gentle and broad to permit the guns to be run up and down with ease and safety; and as this labour augments with an increase of height, ramps in high ramparts are proportionally longer that in low ramparts. The average length of ramps are at about eight times their height. As the ramparts in the outworks are lower than those of the enceinte, and as the guns on the former are usually of a less calibre than on the latter, their ramps are neither so long nor so broad as those of the body of the place. Ramps are made at the gorges of the ramparts of full bastions; in the flanks of empty bastions, and in the gorges of the ramparts of ravelins, as seen in fig. 2, Plate I: they are also made from the covered-way through the glacis for the exit of sorties; their tracing is such as to prevent their being enfiladed, as in fig. 2: they are usually 30 feet long, 12 feet broad, and are closed by barrier gates of palisades. Although

the interior slopes of ramparts can be ascended and descended, as they are only natural slopes of 45°, yet they are too steep for easy or common communications; and staircases are sometimes made in the centres of the curtains; (see fig. 2, front B N) but, in general, the ramps are sufficient for all needful purposes. It has been recommended to substitute ramps for staircases wherever it can be done; and a sufficient space for their construction is, in general, the only obstacle to its being done.

142. Lastly. Safe and assured communications between the different works, and especially between the enceinte and the outworks, are of the first importance. It is absolutely necessary, for the good defence of a work, that there should be the means of succouring it, by reinforcements, through safe and convenient passages; of relieving the troops on duty; of withdrawing them in safety when they can resist no longer, &c.: and this can only be done by a sufficient number of the communications described above: they are therefore indispensable; not only as they affect the actual means of resistance, but also from the influence they have on the moral feeling of the soldier; who performs his duty with a much greater degree of confidence and cheerfulness when assured of aid, or of a safe retreat if overpowered.

143. *In plan-drawing*, it is customary to represent all the masonry work in red lines, and the earthen works in black: the cordon or master-line of the escarp is a thick red line, and all the crests of the parapets are in thick black lines. The tint of Indian ink, for shading, should be very light, and all slopes shaded down, from top to bottom, with a water-brush. To ornament the plan, the rays of light are supposed to enter from the upper left-hand corner of the paper; and all slopes that face it are but lightly shaded, while those that recede from it are

FIELD FORTIFICATION.

PART II.

CHAPTER V.

DIMENSIONS OF FIELD PARAPETS. DITCHES AND TRENCHES. SIZE AND CAPACITY OF FIELD-WORKS. TRACING FIELD-WORKS: AMOUNT OF EXCAVATION. DESCRIPTION OF GABIONS, FASCINES, &c. BRIDGES. OBSTACLES.

144. In field fortification the height of the parapets varies from 6 to 12 feet, and their thickness from 3 to 12 feet, according to the purposes for which they are required, and the positions they may occupy. Reference must be made to article 55, page 16, Chapter I, on the penetration of missiles, and the proper thickness of parapets to resist them; but as 18 and 24-pounders rarely form part of a field equipment of artillery, field parapets seldom exceed 12 feet in thickness.

145. The object of the ditch being to create an obstacle to an enemy's approach, and to obtain earth from it to construct the parapet or breast-work, its capacity chiefly depends on the demand for the latter. This obstacle can be increased by deepening and widening its dimensions; but to do so beyond its due limits, gives more earth than is required; to excavate and remove which takes time and labour.—— The means usually available for the construction of field-works, will seldom admit of the ditches being made more

than 12 feet in depth: and they generally vary from 6 to 12 feet deep. These means likewise affect the height and bulk of the masses of the parapets, which, under ordinary circumstances, never exceed 12 feet in height.——The height of a parapet must be such as to give good cover to the defenders in its rear; and when the contending parties are on nearly the same level, nothing less than $7\frac{1}{2}$ feet can be considered as sufficient for this purpose.——But if a work be intended merely to cover a guard, or to hold out against a sudden assault, a parapet of 6 feet high will, in many cases, be sufficient.——A difference of level in the ground, either within or without the work, will invariably affect the height of the parapet: if, for instance, the defensive position is on the brow of a hill, and the ground to be commanded be low, a parapet 5 or 6 feet high would probably answer every purpose, see fig. 20, Plate VIII; but if the work be in a hollow, or on low ground, the height of the parapet must be augmented to 8, 10, or 12 feet, according to circumstances, so as to screen the defenders from any commanding ground that an enemy may occupy.——In general, the banquette is assumed to be from 4′ 3″ to 4′ 6″ below the crest of the parapet; the tread is 3 or 4 feet wide, with a slope of 2 inches to the rear; and where the slope of the banquette would be too great to be made double its height, it is broken into steps from 9 to 12 inches rise, having a tread of 1 or $1\frac{1}{2}$ feet wide, with a little slope to the rear to carry off rain water: by this arrangement, the quantity of excavation is diminished, as well as interior space saved. The exterior slope is at 45°; the interior slope is 1 foot; the depression of the superior slope $\frac{1}{8}$ or $\frac{1}{6}$ of its thickness. See figs. 7, 8, and 19, &c., Plate VIII.——In fig. 8, the scarp, or front slope of the ditch, is represented as nearly one line from the foot of the superior slope of the parapet to the bottom of the ditch; and

this construction is assuredly more difficult for an enemy to overcome, than a parapet with a berm ; * but this berm is of great use in the construction, as it gives a step or footing for the workmen ; and should the work have to stand for any time, or should the soil be loose, the berm gives it greater stability ; its advantages, therefore, are such as to induce engineers, in many cases, to prefer it to the continued slope. These profiles, however, need not be adhered to ; the nature of the soil, in some cases, requires great slopes to be given to the parapets and sides of the ditches. In the celebrated lines of Torres Vedras, the profiles had generally a berm of two feet, and the sides of the ditches sometimes nearly met in an angle at the bottom, as fig. 19. This was a judicious construction, as the redoubts in these lines were rarely flanked, and thus anything like a settled formation of troops in the ditch was prevented. The defenders, on this occasion, were abundantly supplied with that most useful weapon, hand-grenades, to shower over the parapet into the ditch, to supply the want of a flanking defence.

146. It is almost impossible to fix dimensions for parapets and ditches on sloping ground, two cases are given in Plate VIII: see figs. 20 and 21. In fig. 20, the height of parapet would entirely depend on the undulations of the hill: should the ground rise at *c d*, then the height of the parapet may be only 4 or 5 feet from the apex of the rise: the dotted lines *e* and *f* show that more or less cover is obtained behind the parapet as the slope of the hill may follow one or the other of these dotted lines. Any earth which may be to spare in giving proper dimensions to the ditch, may be usefully employed in forming a glacis. With

* A berm is a flat space or step, of a few feet in width, between the foot of the exterior slope of the parapet and the front slope of the ditch, as in figs. 7 and 19.

regard to fig. 21, where the work is supposed to be on the general slope of a hill; it is clear that such a profile is applicable only to a line of works; and that such a position would rarely suit an enclosed work; the best mode of proceeding would be to have a trench in rear of the parapet, that the troops manning the parapet may be fully covered. These two figures are merely specimens of what might be multiplied by showing various kinds of slopes, such as occur in every country, and which must be thoroughly studied in taking up defensive positions: the dimensions given for figs. 20 and 21, are merely as an example.—— From what has been said, it may be seen, that although there are general principles to be followed as to height and thickness, yet that the application of these, in detail, depends on the peculiar circumstances in which the works may be placed, and the features of the ground on which they rest.

147. It is necessary on many occasions to excavate in rear of the parapet, and to form a *trench* covered in front by the parapet. This is the usual figure of offensive works and batteries, as seen in figs. 1, 2, 3, Plate VIII: (in all cases, the amount of excavation from the ditch in front, or from the trench in rear, depends upon the quantity of earth required to construct the parapet:) the examination of these figures will show the kind of cover usually obtained for troops, from a mere screen to a substantial parapet, proof against 12-pounders. The usual depth of trenches is 3 feet, as it is easy to step in and out of them by means of a single step, as seen in figs. 1 and 2. These trenches should always slope to the rear, and, in case of wet weather, care must be taken to direct their soles or bottoms so as to fall into the natural ravines or hollows of the ground on which they are placed: besides which, cesspools, one foot square or more in dimensions, should be made, as in

figs. 1, 2, and 3. Should the nature of the ground be such as to prevent the proper quantity of soil being obtained from the trench in rear, in consequence of its being either swampy or rocky, a small ditch must be dug in front, as in fig. 9.

148. *Capacity of field-works.* The periphery of a work, and the number of men to defend it, should bear a just proportion to each other: for this purpose, three running feet of parapet is required for each man to use his arms freely; and if a file of men be told off to each running yard, the front and rear rank man changing places on the banquette as each fires, then the number of yards and the number of files for each face agree, and no difficulty occurs; for no deduction need be made for the space occupied by artillery; as the spare men arising therefrom will form a reserve to fill up casualties or to meet a sudden assault at any point. Should there be no artillery, a reserve of one-fourth or one-fifth of the whole may be provided.

It has been customary, in calculating the area of enclosed field-works, to allow 10 square feet for each man, and 324 square feet for each gun and its stores; an estimate that need be attended to only in the case of the garrisons of the redoubts being always confined within the parapets: this is rarely necessary; for, during the day, their drill, amusement, and cooking, will be without; and in case of attack, in a system of works, the general formations of the troops will also be without, while the redoubts have only their parapets lined.

149. When a work is traced on the ground, strong pickets are driven at all the angles, and the lines joining them distinctly scored with a pickaxe or spade; two profiles should be set up on each line to show the workmen the form of the parapet, and to guide them in the execution of their task. On long faces, three or more profiles should

be set up. These profiles, when made with straight slips of deal or other wood, show with great accuracy the form of the parapet, &c. To set up a profile (see fig. 83 *a*, Plate X), first drive in the square-headed pickets, and to them nail firmly the upright slips, in order to obtain the proper shape of the parapet. If profiles are set up showing the several angles formed by the parapet, they will be of great assistance to the workmen: the dimensions of these must be fixed by producing the faces of the work. Having set up the profiles, trace with a pickaxe the escarp and counterscarp lines. In constructing trenches and parapets for hasty cover, profiles are not used.

150. *Amount of excavation.* When the situation for a redoubt or field-work has been fixed upon, the slopes of the ground should be well examined, and drains prepared before the work is begun, especially in works enclosed on all sides, as redoubts, &c. Without this precaution, the interior of the works would become pools of water in heavy rains. Before commencing the excavation of the ditches, it is desirable to know how deep they can be made; pits should therefore be sunk where the ditches are to be excavated, in order to ascertain the nature of the soil, and whether rock or water will prevent the ditches going beyond a certain depth: the nature of the soil in these pits will enable the officer charged with the construction to determine upon the proper depth for the ditches. The reader is referred to *Appendix* [*A.*]* in order to become conversant with the mode of calculating the quantity of earth to be excavated in order to form the parapets, &c.; as well as the amount of work that ought to be done by the working parties, and other arrangements connected with the practical details of constructing field-works.

* See Appendix A.

151. *Fascines* are usually made of good strong brushwood laid in a bed or cradle of tressels, as seen in fig. 22, Plate VIII, where the tressels are at about 4 feet apart: two levers, united by a rope or chain about 4 feet in length, are used to choke the fascine, by being passed round it, and pressed by men on opposite sides, till the brushwood is about 9 inches in diameter: for which purpose there are two marks on the rope or chain, at 14 inches on each side of its centre (that is, 28 inches apart), and the fascine is increased or diminished in substance till these marks meet in choking it closely: before the *choker* is removed, a strong withe or *binder* is passed round the place where it is compressed, and firmly fastened: these binders are at about 18 inches apart, and much of the goodness of the fascine depends on this fastening. A good 9-inch fascine, with a little earth outside of it, is proof against musket shot. Fascines are made of various lengths and diameters, according to the required purposes; but the usual dimensions are 18 feet long, and 9 inches in diameter: such a fascine would weigh about 140 pounds, and can be made by 5 men in 1 hour, including the cutting of the material when at hand in a wood. With the fascines, bundles of strong pickets are prepared, in the proportion of 6 to each fascine: the pickets should be about 4 feet long, and one and a half inch in diameter: they are used to fix the fascines into the earth, and to each other, as they are built up to form a revetment. These fascine pickets are driven through the thickness of the fascine into the earth, in building up the parapet. (See fig. 25, for the section of a fascine revetment.)*——In constructing a field-

* The lower part shows the fascine pickets driven through the fascines, to pin them tightly to the parapet: but if the soil be loose, loops of a strong cord or withe are placed round the fascine and carried into the solid part of the parapet, and those fastened down, as seen in the upper part of fig. 25, by anchoring pickets.

work, the number of fascines required to revet is readily found by the following rule:—Divide the length of the work by the length of the fascines, and divide the height of the work by the thickness of the fascines; then multiply the two quotients together for the number required.—— Fascines will sustain slopes of earth with a base of one-fourth of their height: ten rows will be required to sustain the interior slope of a parapet 7½ feet high without a banquette, and six rows with a banquette. Besides these long fascines (or, as they are often called, saucissons), there are shorter and smaller fascines used in carrying on the work of the trenches at a siege. These *trench-fascines* are about 4 or 5 feet long, and 6 inches thick; there are also thick fascines of 18 inches in diameter, and from 6 to 9 feet in length, called *water-fascines*, used to cover a wet surface: and in crossing wet ditches, they are sunk with stones in layers to form a causeway. A small kind of fascine is used in sapping, called a *sap-fagot;* they are usually 3 feet long and 9 inches thick, having a strong sharp-pointed stake through their middle to fix them into the ground.

152. *Gabions*, or cylindrical baskets, open at top and bottom. To construct these well, the men employed must be acquainted with basket-work in all its parts.——Gabions are of various dimensions, according to their intended use. When required to revet the steep interior slopes of batteries, two upright rows of them should equal the full height of the parapet; in this case the basket-work is strongly and rather coarsely made; but in the sap-gabions the work is carefully *waled* and finished.—— To construct a *sap-gabion*, as in fig. 23, a circle of 20 or 22 inches in diameter must be traced on a clean hard level piece of ground: each quarter of the circle is divided into four or five parts, and small holes, made at the points

of division, to receive straight uprights of 3½ feet in length, around which the withes of the basket-work are *waled.* When finished, the gabion is 2 feet 9 inches or 3 feet high: the ends of the uprights are cut off, and the work is firmly stitched together from top to bottom in several parts. A sap-gabion carefully made and finished, generally weighs from 20 to 40 pounds, and occupies 4 men for 1 hour in making it. To revet an interior slope with gabions of these dimensions, see fig. 26, two rows of sap-gabions and two of fascines will be necessary to complete the slope, retained at one-fourth of its height. With a banquette, one row of gabions and one of fascines will complete the slope; or in a battery like fig. 29, one row of gabions and two of fascines.

153. *A sap-roller*, figs. 71, 72, 73, Plate IX, consists of two large concentric gabions, each 6 feet long: the greater one has a diameter of 4 feet, and the lesser one of 2 feet 8 inches: both these gabions are very strongly made, and the interval between them is stuffed with pickets of hard wood, not less than one inch thick, which renders it musket-shot proof. It occupies 8 men for 12 hours to make such a sap-roller; or the sap-roller may be the larger gabion stuffed with hard fascines, so as to be musket-shot proof: the French practise this; but it is considered too heavy in the British service, where the two concentric gabions are preferred.

154. *Hurdles* are useful in temporary works, to retain earth at a steep slope for a short time, &c.: when thus used, anchoring pickets should be introduced to secure them. They are usually made 3 or 4 feet high, and from 6 to 9 feet long. Hurdles are handy in the trenches, especially in wet weather, to form a firm footing: also in the construction of the passages of wet ditches. At the siege of the citadel of Antwerp, in the winter of 1832, the ground of the

trenches was so inundated and rotten as to require layers of fascines and hurdles to give it solidity.*

155. At page 192, vol. ii, of Sir John Jones's Sieges, the following judicious remark is made :—"No general rule for the size of materials and implements can be laid down: but in arranging the dimensions of fascines, gabions, splinter-proofs, &c., for any service, it behoves a British officer to consider well the nature of the trees and shrubs to be found in the country where the army may be acting; or, otherwise, following the rules taught in books, he will find himself occasionally in a sad dilemma. For instance, in the early part of the war, it happened, in making the preparations for the attack of a post in the West Indies, the superior density of the wood peculiar to tropical climates not being adverted to, the fascines and gabions were prepared of the usual dimensions; and, in consequence, none of the original supply could be made available in the trenches from their great weight. Fascines and gabions made in summer will also weigh more than those made of similar boughs in winter. Where brushwood or other material is scarce, or difficult to be procured, it should be recollected that the content of fascines of equal lengths, being as the squares of the diameters, much will be saved by making them of small bulk."

156. *Sand-bags* are extremely useful for reveting the steep interior slope of field batteries, &c., figs. 24 and 27, Plate VIII: they will retain earth at a slope of about one-fourth of its height; and as they are intended for very temporary purposes, the canvass of which they are made may be very coarse. When the soil on which a lodgment is made is rocky and bare, bags of sand are built up or thrown into gabions to give cover. These bags are usually made up in

* In crossing the numerous sloughs and rotten ground on the unformed roads of India, brushwood, hurdles, and fascines, will be found very valuable.

bales of about two hundred each: their dimensions are seen in fig. 24, where they are described. When full, they hold a bushel of earth, and are musket proof, and weigh about 60 lbs.; and a man can carry one with ease. Sand-bags do not make a good lining for the cheeks of embrasures, as the bags burst from the explosion of the guns and take fire.——There should always be a good supply of sand-bags for siege operations, both in the attack and defence, for obtaining cover rapidly, by sand-bag parapets, traverses, &c.; for loop-holes for a musketry fire; for tamping galleries of mines, &c. ——Bales of cotton, woolpacks, bags of hay, &c., built up or stuffed into frames or gabions, (as fig. 42) serve to obtain a temporary cover from a musketry fire; but these, as well as fascines, are apt to take fire when there is not a sufficient quantity of soil to fill and cover them; thus, in the attack upon the Havanna by the British in 1762, the same parapets of fascines were burnt twice.

157. When a parapet is constructed to furnish a close musketry fire against a work, and is therefore itself exposed to the same, it is customary for both parties to cover their men as much as possible, by forming loopholes for them to fire through; this is done with sand-bags: two are placed so near as to leave a small opening between them, and a third on top resting its ends on two beneath. The two sand-bags are placed lengthways and perpendicularly to the crest of the parapet at 5 or 6 inches apart, and one transversely over them: being musket-shot proof, they form an excellent loophole. See fig. 34, for details of loopholed pits for light infantry or riflemen.

158. *Sod revetments.* Fig. 28 gives the necessary information on this subject. The sods should be cut from meadows well provided with grass, previously mown; and, if possible, watered, that the earth may more firmly adhere to the roots of the grass. The sod-work is laid with the grass

downwards, alternately headers and stretchers, as in brick-work, so that the joints of no two rows fall immediately over one another. If the layers of sods are laid perpendicular to the slope, they will resist the thrust of the parapet better than if laid horizontally. Each sod should have two or three pegs driven through it to secure it to the work beneath. Sod-work can be made with great perfection and very durable. The size of the sods depends upon the nature of the soil and of the grass. In meadows, the sods may be 12 or 18 inches long, 12 inches wide, and 4 or 6 inches thick. In heath, having large roots, they may be 2 feet long, 12 or 18 inches wide, and 8 or 10 inches thick.

159. *Stockade revetments.* When the earth will not stand at a slope of one-third, as is very generally the case, the escarps of important works should, if possible, be made difficult to escalade. Trunks of trees form the best description of protection for escarps. They should be planted vertically, and touching each other, their ends sunk 3 or 4 feet into the earth. When the escarp side of the ditch is covered in this manner, the earth in the rear may have its natural slope; and the trunks of trees may be placed either at the foot of the slope, or, when a line of musketry fire is required, at 4 feet in front of it. In this case, loopholes are pierced in the timber 3 feet apart, and it is called a *stockade.* The ditch must be made deeper in front than in rear of the stockade, to prevent the enemy closing on the loopholes; and ready means of communication between the interior of the work and the ditch should be provided. But it is evident that this is not suited for a work, the ditch of which can be taken in flank. When a field-work is of much importance, and it is desirable to revet the escarp, and to retain it at a slope of one-fourth of its height, then none of the methods described for interior revetments would be sufficient; and a revetment of timber is the only one that would answer without resorting to

masonry. This may be done by means of strong beams nearly upright, at 4 or 5 feet from each other, that hold in a series of horizontal planks: they are sunk $2\frac{1}{2}$ feet in the ground, and attached to horizontal beams, strongly bound and tied by others within, so as to resist the pressure of the earth against the planks. This, however, is of rare occurrence, as it requires plenty of good timber, active carpenters, and time.

160. *Bridges of communication.* To communicate with the interior of a work, a bridge must be formed across the ditch. This bridge will generally consist of two parts, one standing or permanent, the other movable. If the ditch be not more than 12 feet wide, the whole bridge may be made movable. Four or five sleepers laid across the ditch, of not less than 6″ by 4″ are covered with planks: a piece of smaller scantling or ribband is laid on the top of the planks immediately above the exterior sleepers, to which it is secured with *rack-lashings*, notches being cut in the ends of two adjoining planks for their introduction.*——When the ditch is more than 12 feet wide, a tressel or frame must be placed in the

* The rack-lashing consists of a piece of stout rope fastened to the thick end of a pointed stick: the rope is passed round the piece of timber to be secured, then twice round itself; the end of the stick is then put into the loose *gromet* so formed, and twisted round until the whole is firmly secured, when the stick is turned flat on the outer side of the ribband. These ribbands and rack-lashings may be seen in section in the platforms, represented in fig. 15, Plate VIII. The larger shaded square is the section of a sleeper: *d* is the section of one of the planks forming the flooring: the smaller shaded square is the section of a ribband: the unshaded part between the two squares is the notch, or opening, made in the plank of the flooring: *a c e b* is the rack-lashing: *s* is the end of the rack-stick in its grommet. These rack-lashings are at equal intervals along the bridge or platform, in order to bind the whole firmly together, which it does most effectually; and rack-lashings have the advantage of rapid execution, no noise, and no injury to the timber.

middle to support the sleepers of the bridge. The height of the frame will depend on the depth of the ditch. The transom or upper piece should be 10 feet long, and the legs be wider apart below than above, in order to give steadiness to the bridge. When a bridge is more than 24 feet long, two or more tressels must be placed in the ditch to support it. These supports should not be more than 12 feet apart. The sleepers should be from 7 to 8 inches square, and all except the last bay of the bridge may be permanently fastened; a piece of scantling or ribband being nailed over the planking on each side of the bridge, to prevent the wheels of carriages, &c., going too near the sides. When rough timber only can be procured, and no plank, a bridge may be formed much in the same manner as already described: stout straight limbs must be selected for the sleepers, which should have but short bearings; they may then be covered with strong hurdles, over which a layer of sods, and then a small quantity of gravel may be laid.

	To support Artillery.	To support Infantry.
Number and scantling of baulks and sleepers	5 or 6 sleepers 9″X9″	2 or 3 sleepers 6″X4″
Thickness of planks	2½″	1½″
The width of the bridge	10 feet.	3 to 5 feet.

161. *The obstacles* usually added to render the approaches to field-works and the possession of them, more difficult to the enemy, are as follows: palisades, stockades, barriers, abattis, trous-de-loup or trap-holes, chevaux-de-frise, harrows, crows'-feet, fougasses, and inundations: some of these obstacles should be formed with great attention, as it greatly daunts the ardour of the best assailing troops to be checked, and to have their formation broken, under a near fire of musketry, without the power of immediately closing with their opponents.

162. *Palisades.* Sir John Jones, in the first volume of his Sieges, page 471, says, "The French plant admirable palisades in the ditches and rear of their works: each palisade is the rough stem of a young tree, or the half of a larger tree fixed to a heavy beam 4 or 5 feet under ground. To cut through these palisades, in their usually confined situations, is the work of half an hour, and to force them out is impossible, so firmly are they planted. They are therefore, an excellent defence when covered from cannon." —— Palisades are fixed in ditches as shown in fig. 8, Plate VIII: when inclined, as on the front slope of the ditch, they are called *fraises*: they are not much approved of: a good range of these on the escarp (nearly horizontal) served, in one instance, during the Peninsular war, to place the scaling ladders against, and to give the assailants a tolerable footing before rushing over the parapet. In a scarp slope, a range of palisades at its foot, as described in paragraph 159, forms a kind of revetment, which may be made very formidable when the wood is of a large rough scantling: and on the other side of the ditch they are also useful and difficult to cut down, should the assailants attempt to descend the counterscarp. Square beams of timber, from 12 to 9 inches square, cut diagonally, are suited for palisades. Iron fraising in particular positions may be found very useful.

163. *Stockades* are strong timber walls; or palisades touching each other, and loopholed for musketry.* The

* A native stockade of Donoobow, in Burmah, extended for nearly a mile along the sloping bank of the Irrawaddy. It was composed of solid teak beams, from 15 to 17 feet high, driven firmly into the earth, and placed as closely as possible to each other. Behind this wooden wall, the old brick ramparts of the place rose to a considerable height, strengthening the front defences by means of cross beams, and affording a firm and elevated footing to the defenders. Upwards of 150 guns and swivels were mounted on the works, and the garrison was protected from the shells of the besiegers by numerous well contrived traverses and excavations. A ditch of considerable magni-

timber should not be less than 9 inches square, with a height of 8 or 9 feet out of the ground, and sunk into a good trench, 2 feet under ground. If made of young trees, the interstices may be filled in with half trees trimmed and made as high as the loop-holes, that is, about 4 feet from the ground: in this case, a trench would be necessary about 3 feet in rear, that the troops within the stockade may be covered; moreover, in order to protect the timber as much as possible from being battered, a ditch may be made in front, and the earth formed into a kind of parapet as high as the foot of the loop-holes. See figs. 37 and 43, Plate VIII. Stockades serve to bar up passages, streets, avenues, gorges of field or advanced works, and are very formidable defences in countries abounding with timber. Covered passages or caponiers, as seen at H I, fig. 45, Plate IX, are usually made of a double stockade; in the ditch of fig. 46, there is a longitudinal section of H I, and in fig. 48, a transverse section. It is evident that this arrangement may be carried out on a great scale in making stockaded barracks and redoubts.

164. *Barrier gates*, to close in the entrances of field-works, should be very massive, and capable of resisting any

tude and depth surrounded the defences; the passage of which was rendered more difficult by spikes, nails, holes, and other contrivances. Outside of the ditch were several rows of strong railing: and in front of all, an abattis, thirty yards broad. Against this formidable enclosure, heavy artillery was put in battery, and breached sufficiently to allow of its being stormed by the British troops, in 1826.

Another Burmese stockade, which was attacked and carried by General Sir Archibald Campbell in 1826, is thus described:—It had a breast-work with loopholes; crows'-feet of pointed bamboo, hardened in the fire (they give great wounds when run against, and have occasioned loss of limbs); beyond this, palisades; then a range of abattis; then a ditch, from which the earth was taken for the parapet; inside these was a covered shed all round the work. These stockades were square in their tracing, and had an area of about 400 square yards, which required about 100 or 120 men to defend them.

sudden attack. They may be made of strong stockade or palisading, swept by the fire of a traverse, and are always placed on the least accessible side.

165. *Abattis* are lines of felled trees of a considerable size: their stems strongly bound together and picketed down, while their branches are spread towards the enemy, and interlaced as much as possible: the small branches are cut away and the boughs well pointed. Fig. 8, Plate VIII, is one instance of placing an abattis where it is covered by an advanced glacis that hides it from the view and the fire of the enemy's artillery: and in forcing this abattis, the assailant is exposed to the full fire of the parapet in the rear. Good positions for abattis would be at the angles of the square redoubt, fig. 45, Plate IX, especially at the opposite angles A and G, in order to increase the difficulty of an enemy's approach to the galleries that defend the ditches. Well disposed abattis make formidable obstacles, and have always been highly esteemed and much used in ancient and modern warfare.*

* At page 360 of the third volume of Col. Napier's History of the War in the Peninsular, in describing the lines of Torres Vedras, it is said: "Across a ravine on the left, a loose stone wall, sixteen feet thick and forty feet high, was raised: and across the valley of Aruda, a double line of abattis was drawn, not composed, as is usual, of the limbs of trees, but of full grown oaks and chestnuts, dug up with all their roots and branches, dragged by main force for several hundred yards, and then reset and crossed so that no human strength could break through. Breast-works, at convenient distances, to defend this line of trees, were cast up, &c."

A striking illustration of their value and importance in retarding the advance of troops, was furnished in the Mahratta war of 1817 and 1818, in the case of a division of the British army with a siege train, employed in the capture of the Peishwa's fortresses in the Concan; a mountainous district peculiarly difficult for such movements. Forest trees were sometimes felled by the enemy, and so laid as to interlock immediately across valleys and ravines in the path of our army: not unfrequently supported by direct and flanking fire from matchlocks and iron rockets. Had these very strong positions

166. *Trous-de-loup*, or trap-holes, are rows of pits in the form of inverted cones or pyramids made before a work, and having a strong palisade or stake in the centre of each: these used to be about 6 feet deep, and 8 or 10 feet diameter at the top: but upon some occasions, during the Peninsular war, bold and active riflemen crept into them, and brought a destructive fire from them upon the defenders; to prevent which they should be made too deep, or too shallow for the convenience of riflemen; that is either 8 feet or $2\frac{1}{2}$ feet, deep. In tracing trap-holes, they should always be chequered to prevent an enemy passing them easily.—— Farmers' harrows may be used with advantage as obstacles, strongly picketed down to the ground.——Crows'-feet are triangular pieces of iron, used as obstacles to the advance of troops, especially of cavalry.

been at all adequately defended, they might have cost the advancing army dear to effect a passage, from the impossibility in many cases of moving the heavy artillery and stores by the flanks. And even when these had been turned by light troops, and the position gained with serious loss of life on both sides, the progress of the army was still further delayed until the gigantic abattis could be burnt down, the only practicable way of effecting a passage, thereby giving time to the retreating enemy the better to prepare their adjacent fortresses for a siege.

CHAPTER VI.

USUAL TRACINGS FOR OPEN FIELD-WORKS; FOR CLOSED WORKS; AND FOR LINES. BRIDGE-HEADS, &C.: SPECIMENS OF THEIR APPLICATION.

167. *Usual tracing for field-works.* The tracing depends upon the situation and importance of the works; the number and species of the troops; and the quantity of artillery intended to occupy and defend them. It is usual to divide them into three classes:

First, works open at the gorge. Fig. 58 to 63, Plate IX.
Second, works enclosed all round. Figs. 68 to 70, ditto
Third, lines; connected. Figs. 64 to 67. Lines at intervals. Fig. 82, Plate X.

Redan, ...	Fig. 58	are the names given to the various tracings of the first class, or open works.
Lunette, ...	„ 59	
Redan with flanks, . .	„ 60	
Double Redan, . . .	„ 61	
Tenaille-head, . . .	„ 62	
Bastion-head, . . .	„ 63	
Redoubt, ...	Fig. 68	are the names given to works under the second class, or closed works.
Star fort, ...	„ 69	
Bastioned fort, . . .	„ 70	
Indented lines (à crémaillère) .	Fig. 64	are the names given to the works of the third class, or lines.
Lines of redans, ...	„ 65	
Lines of tenailles, ...	„ 66	
Lines of bastions, ...	„ 67	
Lines at intervals	„ 81	

168. The following maxims are necessary to be observed in the construction of field-works:——1st. That the works to be flanked are never to be beyond the range of the weapons of the works flanking them; that is, never out of the effective range of musketry, or from 140 to 180 yards. This flanking defence should be particularly attended to; that is, in attacking any portion of a work, the adjoining portion should be so disposed as to bring a cross fire upon the assailants, which coming upon his flank as he advances, is called a *flanking fire*. This remark extends to all defensive works, towns, villages, farms, outhouses, gardens, enclosures, &c. In occupying such places, the roads, streets, avenues, and approaches, should be seen in flank, so that an attack on one part shall be flanked or defended by neighbouring parts.——2nd. That the angles of defence should be about right angles.——3rd. That the salient angles of works should be as obtuse as circumstances will permit.——4th. That, although ditches cannot always be as fully flanked, as in permanent fortification, yet that partial flanking must be carried as far as possible.——5th. That in the construction of field-works, reference should not only be had to the direct and immediate obstacles that the work itself presents to the enemy, and the positive effects of fire on the approaches to it; but likewise the relative value of the work must be considered, as to the support it can give to, or receive from, other works.——6th. That the outline of a field-work should be proportioned to the number of men intended to defend it.——7th. The ground over which an enemy must pass to the attack should, if possible, be seen both in front and flank.

169. *Redans* (fig. 58, Plate IX,) are the simplest kind of trace for field-works; having two faces, forming a salient angle: they serve to cover bridges, causeways, avenues, &c., and being quite open at the gorge, are only suited for defence

when resting their extremities on rivers, or obstacles which prevent their being turned; or else, when within the full sweeping fire of works in their rear, that an enemy may be deterred from any attempt to assault by the gorge. Redans in front of other works are generally mere cover for an advanced post: for example, if a strong redoubt occupies the commanding summit of a hill, as *e*, fig. 82, Plate X, its elevation and position usually prevent the deep hollows and approaches by the vallies being fully seen from its faces; redans or flèches, *a''* and *b''*, may then be advantageously constructed on the lower knolls, or under features of the hill, to see into all the hollows, while the fire of the main redoubt plunges into their interior. When there is time, redans are provided with flanks, fig. 60, Plate IX, at about 50 or 60 yards (or half musket shot) from the flanked angle. These flanks should be from 10 to 20 yards long, and perpendicular to their faces, so that their fire should flank the capital. Redans have the defect of unflanked ditches; their profile should therefore be like that represented in fig. 19, Plate VIII, and the defenders should be provided with hand-grenades to throw over the parapet for the defence of the ditches.——Redans having flanks parallel to their capitals, are called *lunettes*, fig. 59 : the position and extent of these flanks depend upon the purpose for which they are made, and the ground that they have to flank, as *a*, *a'*, *a''*, *a'''*, fig. 82, Plate X. Two redans joined together, as fig. 61, Plate IX, form a double redan ; a shape and size that may, in some cases, be more convenient than the single redan ; besides which, the re-entering faces mutually defend or flank each other : this double redan gets the name of *tête à queue d' hyronde*. The re-entering angle should be as near a right angle as possible ; the front about 80 yards ; the salient angles never less than 60° ; and the flanks about 20 yards. Should the ground to be defended

require more important and extended works than these, the bastion head should be used.

170. *Tenaille heads* are traced as fig. 62, the fronts 80 or 90 yards ; but if the ground admits of, or requires, a greater extent of front, a bastioned head may be constructed of dimensions suitable to the ground.

171. *Bastion heads.* See fig. 63. The length of the fronts depends upon the ground to be occupied, varying from 100 to 200 yards: beyond 220 yards, the line of defence for musketry becomes uncertain. The application of works open at the gorge is seen in figs. 80, 81, Plate X, which represents the defence of bridges across rivers. ——Another instance of their application is seen in fig. 82, Plate X, which supposes the defence of a position by lines at intervals: the open works, *a*, *a'*, *a''*, *a'''*, *b*, *b'*, *b''*, *f*, being placed in the first line, having their interiors and ditches flanked by the fire of the closed works, *c*, *d*, D, *d'*, and *e*, on the second line.——The extremities of all works which have to be defended by works in their rear, as the open works in fig. 82, should have their ditches flanked by being sloped upwards, like a ramp from the bottom, in order that they may be seen and defended by the fire from the works in the rear: and in many cases it may be proper to close the gorges of such works by a good stout loop-holed stockade, to prevent their being carried by a rush in the rear.

172. *Redoubts* are works enclosed on all sides without flanks, of a square, polygonal, or circular figure: the latter form is rarely used, from the unsuitable nature of such an outline to ground in general ; and the total impossibility of giving any flanking defence to its ditch. Redoubts are commonly square or pentagonal figures in their trace, as each front can then furnish a steady strong fire perpendicular to its face, as in fig. 82. D, *d*, *d'*, *c*, *e*, are polygonal

and irregular redoubts, traced according to the shape of the hill. Whether the outline be square or pentagonal, every endeavour should be made, in tracing a redoubt, to direct the faces upon ground either inaccessible or difficult for an enemy to possess; not only to guard against his enfilade fire, but, if possible, to hinder him from approaching upon the angles, and compel him to advance upon the faces, from which comes the strongest fire. A square redoubt having its side of 40 yards along the crest of the parapet, is capable of holding 4 pieces of artillery and 320 men; hence they are never made larger: as if it becomes necessary to construct a work for a greater body of troops, a superior tracing to that of an unflanked redoubt is adopted. In Plate IX, fig. 45, a square redoubt is shown in detail with its sections in figs. 46, 47, and 48. The side of the redoubt is 40 yards in length, measured along its crest; the dimensions of the parapets and ditches are exhibited on the plan and sections; fig. 46, shows a section taken along one of the capital lines, and here the angular dimensions will of course exceed those that are taken perpendicularly across the faces.——The entrance of the redoubt, which is 6 feet wide, having a bridge across the ditch, is defended by a traverse: the length of this traverse is regulated so as to shut in from an enemy's view all the interior of the work; and for this purpose—suppose a man of an ordinary height using a musket outside, the height of his shoulder in discharging his musket would be about $4\frac{1}{2}$ feet from the ground; a musket shot, therefore, flying at this height parallel to the ground from without to the inside, would graze the exterior and interior slopes of the parapet at this height, represented by the dotted lines *a b; a' b'*. The traverse standing at 9 feet from the slope of the banquette must then be a little longer, say 2 feet, than the intersection

of these lines of fire with the parapet of the traverse; this may be seen by examining the figure: and this principle may be applied to all traverses defending openings of this kind. See C D, figs. 45 and 47. This mode however of defending a passage by a traverse, takes much time in construction, and fills up a large interior space, besides the danger of affording a means of entrance to an enemy in a hasty and powerful attack, perhaps before there is time to draw in the bridge. It is therefore recommended to make a sloping gallery of descent from the interior into the ditch, as indicated by the dotted lines, *k l;* and along the reverse slope of the ditch to have a temporary staircase of wood; or a ramp, if guns be required to pass through, as seen at *o p.*

173. The angles of the parapets of this square redoubt are formed with a view of bringing a fire upon the capitals, which have the disadvantage of all such redoubts, viz., having no flanking defence. One angle is broken into a succession of salient and re-entering angles or teeth, called *crèmaillére* (as *r r r r*, fig. 45). The fire from each little side of the teeth, containing perhaps two men, would be either along the capital or perpendicular to it, and thus afford a flanking defence. This is a troublesome, and after all a meagre mode of defending an angle. Another angle M, has an embrasure, by which the redoubt, if furnished with artillery, can bring a good steady efficient fire of round shot or canister upon the capital. The angle O has a barbette mass prepared for a gun to command the ground before it. The angle N has no arrangement for bringing a fire upon the capital.

174. Redoubts have usually the disadvantage of having their ditches unflanked: and in fig. 45, the contrivances to do away with this evil are: 1st, a covered caponier, or double stockade: 2nd, a reverse or counterscarp gallery:

these will now be explained. 1. *A covered caponier* is seen at H I in the ditch on the capital B A: it consists of a double row of stockade, or strong upright beams about 1′ thick and loopholed at every 3 feet, each beam having half a loophole at these parts; figs. 46 and 48 show this construction: should it be feared that an enemy might close with the stockade, and make use of it by firing through the loopholes from without, a ditch or drop may be made all round it, as indicated by the dotted lines at *d d*, fig. 48; but this is not to be feared in the case shown in figs. 45 and 48, because the loopholes are only 2 feet from the ground, which would be too low for an enemy to use. The floor of this caponier being low, even two feet below the level of the ditch, is likely to be damp, and in rainy weather to be filled with water; it is, therefore, a proper precaution to prepare a trench or long cesspool under the floor as at *p*, fig. 48, and to cover it with strong planks. The roof of this caponier is covered with good strong beams, having three layers of 9″ fascines, with binding earth, all covered by a good tarpauling, indicated in figs. 45, 46, and 48. Care must be taken that this caponier does not stretch across the ditch, and thus form a bridge which an enemy might use to gain access to the parapet: it will be seen, in figs. 45 and 46, that there is a space of 12 feet between the top of the reverse slope of the ditch and the caponier, which is usually sufficient. In order to get into the caponier, there is a sloping descending gallery, see figs. 45 and 46, which is made of common mining cases which will be described hereafter.——This covered caponier can defend the ditches on two sides of the redoubt, the loopholes being made oblique for this purpose.

175. For defending the ditches on the two other sides of the redoubt, a reverse gallery is made (as at F): a section on the lines C D, E F G, of fig. 45, is seen at fig. 47: the

faces into flanks, is more than compensated for, by obtaining a good defence for the ditches. The experience gained in the Peninsular war has fully proved that field forts or redoubts, having unflanked ditches, cannot stand against determined and skilful attacks.——All the accessaries, such as fougasses, abattis, trous-de-loup, fraises, palisades, &c., should be used to strengthen bastioned forts in the places considered most suitable for them. Great latitude is given in the construction of bastioned forts, as the exterior side may vary from 100 to 220 yards, and they are therefore suited for many situations.*

178. *Lines.* Continued or connected lines are some-

* On the lines of Torres Vedras, constructed by order of Lord Wellington, to cover Lisbon in 1810, Colonel Sir John Jones remarks on the *trace of several works:* "The redoubts were made of every capacity, from that of one, limited by want of space on the ground it occupied, for 50 men and 2 pieces of artillery, to one for 500 men and 6 pieces of artillery; the importance of the object being the only guide in forming the dimensions. Many of the redoubts first thrown up, even some of the smallest, were shaped like stars, under the idea of procuring a flank defence for the ditches; but this construction was latterly rejected, it being found to cut up the interior space, and to be almost fallacious with respect to flank defence, the breadth of the exterior slope being in some cases equal to the whole length of the flanks so obtained. Even when, from the greater size of the work, some flanking fire was gained, the angle formed by the faces was generally so obtuse, that it demanded more coolness in the defenders than ought reasonably to be expected to aim along the ditch of the opposite face; and further, this construction prevented the fire of the work being more powerful in front than in rear.

"In order to decide on the proper trace of a work, it is necessary to consider whether its object is to prevent an enemy establishing himself on the ground on which it is to be placed, or whether it be to insure a heavy fire of artillery on some other point in its vicinity. In the first case, every consideration should be sacrificed to that of adding to its powers of self defence, by flanks or other expedients. In the second, its powers of resistance are secondary to the establishment of a powerful offensive fire, and its trace cannot be too simple. Latterly, the shape of the redoubts were invariably that most fitted to the ground, or such as best parried the enfilade fire or musketry plunge of neighbouring heights; care being taken to present the

times resorted to, in order to enclose the front of a position, or to connect important redoubts or forts together. Fig. 65, Plate IX, shows the most simple tracing of lines; being redans connected together by curtains; but as the ground before the redans and the ditches of the curtains are only defended by an oblique fire from the portions of the faces of the redans that view them, it is proposed to remedy this partially, by breaking the curtains so as to form nearly right angles with the faces of the redans, as fig. 66; thus modified, they take the name of lines of tenailles.—— Fig. 64 shows the tracing of indented lines; having long faces and flanks perpendicular to them, to defend their ditches: and when these long faces can be directed towards inaccessible ground, or where an enemy cannot establish enfilading batteries, the construction is considered good.—— These indented lines (en crémaillère) are also suitable for connecting important redoubts or large works together as, the long branches can then be directed upon the salients of the great works so as to be defiladed. The dimensions of those shown in fig. 64, in yards, may be used, or increased

front of fire deemed necessary towards the pass, or other object to be guarded; and such will generally be found to be the best rule of proceeding.

"This recommendation, however, is not intended to apply to isolated works of large dimensions, and more particularly to those considered the key of a position. No labour or expense should be spared to render such works capable of resisting the most furious assault, either by breaking the parapet into flanks, or forming a flank defence in the ditch; for the experience gained in the Peninsula shows that an unflanked work of even more than an ordinary field profile, if skilfully and determinedly assaulted, will generally be carried. Nor does the serious evil of curtailing the interior space, which renders any breaks in the outline to procure flanks so objectionable in small works, apply to works of large dimensions; for it must be recollected, that in similar figures, whilst the length of the outline increases only in the simple ratio of the double, triple, or quadruple, the interior space or surface increases as the square of their like sides."

to double the quantity, according to the ground and to circumstances. Fig. 82, *f*, Plate X, is a specimen of indented or crémaillère lines, the long branches of which are directed on the hills *b' b''*.——Bastioned lines, as shown in fig. 67, Plate IX, are the strongest trace that can be given to continued lines, when the ground admits of its being done. A perfectly regular trace, as seen in this figure, is only suited for level ground; but it may be applied with modifications to suit unequal ground.

179. *Lines with intervals.* Fig. 82, Plate X, shows the general trace of lines of this kind: the salient works should never be beyond the range of the musketry, or canister, of the re-entering works; and the angles of defence between the two lines of works should be as near right angles as possible: the ditches of the salient works should be formed *en rampe* (or sloping from the bottom upwards to the level of the ground), in order to receive a flanking fire from the re-entering line of works. The disposition of the works, in fig. 82, supposes ground on which the redoubts, D, *d*, *d'*, *e*, *c*, occupy the most important features of the hills, and that they can see, and flank by artillery or musketry, the open works *a a' a'' a''' b b' b'' f*, which are on lower ground (having their gorges closed by a stockade or good palisades).——The tracing and dimensions of the works composing these lines must always depend upon a great variety of circumstances; such as the shape of the ground; the means and power of the army thus entrenched to assume the offensive, &c. In the case seen in fig. 82, suppose the redoubts, D, *d*, *d'*, to occupy the most commanding knoll, say 200 feet high; the redoubts, *c*, *e*, on lower features 180 feet high; the lunettes and redans on ground 30 feet high; the indented lines, *f*, on the plain below.——It may be seen in this figure, that the great redoubt D, is, in fact, composed of three redoubts connected

together by parapets and ditches, all taking their shape or tracing from the nature of the ground ; that the redoubts *d*, *d'*, are nearly cut off from the great redoubt D, as in the event of one being taken, the passages of communication to the others (usually slight plank bridges) can be removed : were not this precaution taken, of nearly isolating the different parts, the fall of one part would involve in it the possession of the whole, as the enemy could circulate all round when he got in at one part. The great redoubt D, *d*, *d'*, being the key of the position, is provided with 8 or 10 pieces of cannon to flank and defend all the ground and works around : the works open at the gorge are generally within easy musketry range of the redoubts. It might suffice, in some cases, to give the redans and the indented lines, *f*, a trench profile (as in fig. 1, Plate VIII). The river in fig. 82 covers the whole position.

180. Sir John Jones observes, that to cover an extent of country with continued lines, is a most injudicious and weak proceeding: all parts require equal guarding; for if forced at one point the whole is gained; the number of men also that are required to construct and to man so great a development of parapet, as the trace of all kinds of continued lines present, is so great as to demand great means and time, as well as to cramp the power of making any immediate and formidable offensive movement: and thus both defensive and offensive operations are marred by an army having its entire front covered by continual lines. Sir John Jones, however, with his characteristic talent and judgment, remarks that "field defences are not to be indiscriminately condemned or rejected because they are continuous or systematic. In order to strengthen the front of an army with judgment, it is necessary to consider every feature and every portion of the ground separately, and arrange such mode of occupation as shall best combine its

particular defence with the general defence of the position. Thus, in parts unfavourable for manœuvring, it may be advisable to form a continued line of considerable extent, covered with every nature of obstacle, and having none but the most confined outlets, on the principle that a range of difficult heights would be scarped, or low ground inundated, to lessen the number of men on those points, and have a superabundance of force for other points favourable for offensive movements. Again, since the employment of artillery in masses has been introduced, and that an irresistible fire, sometimes of hours' duration, now invariably precedes the advance of the columns of attack, it will frequently prove a good measure, in situations where natural cover cannot be found from a cannonade, to create it artificially between all the prominent defensive posts.* Thus, each furlong of ground being duly considered, and the nature of defence best adapted to the locality being formed, the whole front of an army may occasionally be covered with lines of works, which, while they augment its defensive powers, leave its movements perfectly free."

181. *Bridge-heads*, (see figs. 80, 81 and 91, Plate X,) are field-works generally open at the gorge, resting their flanks upon the banks of a river, in order to cover one or more bridges.——The magnitude and tracing of these works depend upon the importance attached to the bridges: whether they are intended to serve as a temporary or permanent passage during the campaign; whether the army, in retreating, is likely to be exposed to a serious attack in

* This might be effected by means of a sunken trench, like a parallel at a siege, made to connect the whole chain of redoubts. Such an expedient would cover infantry from the fire of guns without impeding their forward movements in line, and openings might be left for the advance of the cavalry and artillery, or they might act in masses on the flanks.

passing the river, &c.——The most favourable situation for a bridge-head is in the re-entering sinuosity of a river; because the work can then, in some cases, conceal the bridge from the enemy's view; as also that, in such a position, the supporting batteries on the opposite side of the river are most favourably situated for aiding the defence and passage of the river.——As têtes-de-pont, or bridge-heads, are usually constructed for the specific object of aiding a retiring army to pass the river in order, and to check an enemy pressing upon it, the tracing and profile of the works must be such as to secure this double advantage as much as possible.—— In the trace, a sufficient number of good openings should be left, as in fig. 80, to permit the retiring divisions, with their guns, carriages, &c., to file through with ease; and parapets so disposed, as seen in this figure, to flank and defend these passages in every direction.*——The various figures shown in figs. 58 to 63, Plate IX, may be used either singly or collectively as bridge-heads, according to the importance of the position: a simple redan with flanks may cover a passage of small importance across a narrow river, supported by a fire of artillery or musketry from parapets on the opposite side. If the river be wider, and the bridge of more importance, it may be covered, as in figs. 80 and 81, by a series of works, and supported by batteries of artillery from the opposite side. Their profile should always be strong, as the pursuing party will not fail to employ masses of artillery to destroy their parapets and uncover the bridge; an interior range of parapets, or a stockade, or a redoubt, would be proper to secure the bridge as long as possible, as indicated in fig. 81, at S S.——The bridge-head in fig. 91, is within the musketry range of a line of hills

* In some cases, a trench and parapet may suffice for the first line *a b c*, fig. 80, having substantial parapets, *e d f*, within them for the second line of works.

(from which it is protected in the interior by traverses). Two good redoubts are made on the opposite side of the river, not only to flank the redan head, but to enable the troops to hold out should it become necessary to dismantle the bridge, or in case of the redan being forced. Indeed, it would be advantageous on most occasions to have good redoubts to protect bridges in preference to open works.——Great têtes-de-pont are works constructed to defend the bridges which cross a river covering part of the frontiers of a state, in order to preserve the communications by which armies may advance into, or retreat from, an enemy's country. In such cases, space should always be left between the fortress and the river, where an army may form and rally, without being obliged to throw itself into the place, and thereby compromise its security.——When separated from an enemy by a river (as in fig. 82) in which there are fords, it is necessary to watch them carefully. The points most likely for an enemy to attempt, are their own re-entering angles.

182. In order to illustrate in some measure the nature of the defences and barriers referred to in the previous articles, the reader may examine figs. 37 to 43, of Plate VIII.——Begin with the simple outline plan in fig. 38. We there suppose that there is an old tower A′, and that at some distance, say 100 or 150 yards, there is a good stone house G′, that there are also two old walls C′ and D′, of different heights—the one 15 feet high, the other 8 feet. Suppose that this ground is required to be turned into a defensible position by any materials that may be at hand. ——Let fig. 37 represent the tower A, the walls C and D, and the house G, in elevation. The tower is furnished with a machiacoulis defence B, with loopholes, to bring a musketry fire on the bottom of the wall and on the country around. (See section in fig. 39.)——Let the general outline be traced

as seen in fig. 38, from the walls to the house, having a small break or flanks in order to obtain a flanking fire.——The high wall, C, fig. 38, can have one tier of loopholes, driven through its brickwork at 8 feet from the ground: and another tier, opened at the top of the wall: these can, of course, be only roughly done; and in rear of the wall—any kind of scaffolding *b b*, *b′ b′*, can be made to enable the defenders to make use of these two tiers of loopholes: fig. 40 is a section of this part of the defences.—— Supposing the wall D to be connected to C, but not so high; a double tier of loopholes can here be made also, a section of which may be seen in fig. 41. To effect this, a trench is excavated behind the wall, or a succession of pits large enough to hold one man in each; and, in order to hinder an enemy from approaching too near a ditch, an upright abattis is made in front of this wall.——If limbs of trees or beams of wood can be placed along the top of the wall, they protect the heads of the defenders; they serve to prevent the wall being easily escaladed, and can be hurled down on an enemy that attempts to do so: it would not always be necessary to cut loopholes in the top of the wall, if trees or timber could be had, through the openings in which the defenders might place their muskets: in rear of this wall there is a step or scaffolding, *d d*, supported by tressels; or a tressel may be placed behind each loophole to enable the men to reach them.——The next defensible barrier is at E, and is made of bales, or packs of cotton or wool, or any material in general use in the country. Fig. 42 shows a section and perspective view of this barrier. A strong rough frame is made to receive these bales, the lower part of which may be filled with two tiers of fascines: boards supported by casks form a banquette, *c*; and in front is a small ditch, with part of the earth sloping up to the foot of the bales of wool. It is at this part that the break, or little flanks, would be made,

which are shown (these flanks are not seen in the elevation in fig. 37) in the outline in fig. 38. The next barrier, F, is a line of stockade, which after being carried on for about 20 feet, turns towards the angle of the house at K, fig. 38. This stockade is 8 feet long, and 9″, 10,″ or 12″ square, fixed to a heavy beam 2 or 3 feet under ground. Loopholes are made at every 3 feet—half of a loophole in each of the beams in every second beam. To prevent an enemy closing with these, and using them from without, a ditch is made in front, as seen in section, fig. 43. In the angle of the house G, an opening is made through the stone, or brickwork, to communicate with the trench I: a parapet or barrier of casks, with felled trees or abattis, as represented at fig. 37, will furnish a fire from the left side of the trench I. It may be observed that the windows of the house are stuffed with sand-bags, or bales of cotton or wool; and that rough loopholes are perforated through the walls, upon the same level as the windows.——In fig. 38, G, the two outer sides of the house have balconies on the first floor, *l l*, which are turned into a kind of machiocoulis defence, as indicated in section fig. 44: the beams supporting the gallery or balcony are bolted to the flooring within; the balcony is surrounded with good oak boarding of 4″ or 5″ thick; having horizontal and vertical loopholes as seen in fig. 44: thus the house G (figs. 37 and 38) flanks all the neighbouring ground, and its base all round is seen and swept by a musketry fire.

CHAPTER VII.

CONSTRUCTION OF BATTERIES. PLATFORMS. FIELD POWDER MAGAZINES.

183. *On the construction of batteries.* Batteries are of four kinds: 1st, *cavalier batteries;* 2nd, *elevated batteries;* 3rd, *sunken batteries;* and 4th, *half-sunken batteries.* The first has the platform for the gun-carriage above the level of the ground: this construction is rare, as it involves great labour, requiring a large excavation, and many workmen to execute it. See Plate VIII, fig. 4.

184. An elevated battery is a complete parapet, the platform for the gun-carriage being laid on the level of the ground; it is in most general use, and in most cases it is the easiest of construction. For the section of an elevated battery, see fig. 5, Plate VIII, and for the plan of such a battery, see fig. 6, immediately below the section.

185. A sunken battery has its level below the ground line, so that the gun can range just above it, as seen in fig. 10, Plate VIII. This construction is frequently used in turning the portion of a parallel into a battery, by increasing the width of the interior excavation of the trench so as to make room for the platforms of the guns. Great care must be taken that no rise in the ground before the battery obscures the view from the soles of the embrasures; for this purpose, the officer laying out the battery should lie down and look along the ground, in order to be sure that his guns can range freely from their embrasures, before he fixes his details for construction. When guns are fired with an elevation (as in the case of the ricochet), this construction is

approved of when the ground is favourable (that is, raised or elevated ground), when the soil is sandy or gravelly, and when the weather is dry; otherwise the interior of a sunken battery becomes a pool of water. The depth of the excavation for the interior must depend on the height of the carriages upon which the guns are mounted: it should be deeper in rear than in front, that it may be drained.

186. A half-sunken battery has both an interior and exterior excavation to furnish earth for the parapet: that is, a trench in rear, and a ditch in front of the parapet: see fig. 9. This kind of battery is suitable to rocky ground where there is only a thin layer of earth. The interior slopes of these batteries, and the cheeks of the embrasures, must be supported by field revetments of gabions, fascines, sand-bags, casks, or sods.——Half-sunken batteries are the most expeditiously constructed of any, as allowing double working parties to excavate and build the parapet; one set of men working in front and another in rear of the parapet. But these, as well as sunken batteries, can only be constructed in the dark, for the security of the men who would be exposed to the enemy's fire whilst excavating in front of the parapet. In cases where securing cover expeditiously is of great importance, or where a shallow soil favours it, this double application of working parties has been found very useful, as it exactly *halves the time usually employed in raising cover* for troops, either in siege operations, or in securing a post exposed to a severe and destructive fire from an adjacent enemy.*

* In the second volume of Sir John Jones's Sieges, at page 170, there is an interesting and instructive memorandum as to the manner of carrying on the duty and performing the work at the sieges in Spain; in which he says, "It was found an excellent expedient to form the interior of the cheek of the embrasures, that is, the part of the opening next the gun, with very strong gabions, made larger than the ordinary size, and placed so close to each other, as only

187. In batteries exposed to a heavy fire, especially of shells, it is necessary to provide as much cover as possible for the men serving in them: for this purpose, traverses are usually placed between every two guns; and as these masses serve to protect the men from the splinters of the bursting shells, they are generally called *splinter-proof traverses.**

to admit the muzzle of the gun between them. This, besides giving great strength to the interior angles, protected the gunners very much from the enemy's musketry.

"In fact, after a few hours of the quick firing, which is now practised from heavy iron guns, the embrasures become utterly shapeless beyond the muzzle of the piece, and all that can be hoped is to preserve two or three feet of tolerable cover next the interior of the battery. During these sieges, the embrasures of the several breaching batteries were fresh lined every night; and though every expedient was adopted to give them strength, still they were invariably found on the ensuing evening to have returned to a shapeless hole.

"Gabion revetments are preferable to fascines, not only for economy in materials, but also in time and labour. Raw bullock hides (doubled) should be stretched tightly over the neck and cheeks of the embrasures to preserve the gabions in heavy firing.

"Most of the batteries at these sieges were thrown up in a solid mass, and the embrasures cut through when the guns were mounted, in consequence of the destructive fire to which they were exposed: but where the fire on a battery was moderate, it was found most expeditious to form the embrasures simultaneously with the parapet."

In the relation of the siege of the citadel of Antwerp, in 1832, published in the 52nd number of the *United Service Journal*, it is stated "that in all the batteries not exposed to direct fire of cannon, the embrasures were furnished with thick musket-proof wooden shutters, opening vertically in their centre, and mounted on frames, with iron hinges and handles. These were opened to point and fire, and immediately closed on the recoil of the piece." (An excellent expedient when within range of the enemy's musketry.)

* In the memorandum of Sir John Jones, quoted in the last article, he says, "Between every two guns a splinter-proof traverse of sand-bags was built up; it was made perpendicular to the parapet, 10 feet long, and 1 foot distant from it at the base, with a thickness of 2 feet at the top. To have ample room for these traverses, it is

188. *Specimen of an elevated battery.* Figs. 4 to 12 must be minutely examined, in order to gain the required information as to the construction and dimensions of batteries in general. It will be observed, that the depression of the superior slope throughout is very small, as a musketry fire is rarely made for these batteries. Very little need be said of fig. 4, as cavalier batteries are seldom made. Fig. 11 is a plan of an elevated battery for four guns and two mortars, have one engaged traverse *c*, and one disengaged traverse *g*, between every two pieces of ordnance; the battery has two short shoulders or epaulements *o y*, *p m*: the plan and profile of this battery is seen on a larger scale in figs. 6 and 5: and it will be observed, that on the edge of the reverse slope of the ditch, there is a line of gabions (fig 5) which would range along the line *k k* of fig. 11: in such constructions, usually made within the range of grape and canister-shot from an enemy, the workmen would, in all probability, place this line of gabions first, excavate a trench in rear of them, fill them with earth, and make a bank or parapet, in order to obtain cover: afterwards, this trench would be enlarged, the earth obtained thrown inwards to form the parapets of the battery. The parapets of the shoulders need not be so thick, as they are usually exposed to an oblique fire: when the battery is completed, and the guns ready to open their fire, this exterior line of gabions, *k k*, is removed in whole, or in part, in order that the guns may have free scope for their fire. On the left flank of fig. 11, it may be observed, that there is a slope or ramp, leading from the interior of the battery

best to place the two guns 18 feet from the epaulement; then leave a space of 22 feet; then 18 feet; and so on alternately, placing the traverse in the larger interval. These traverses in the batteries were of essential service, saving many lives, particularly at Rodrigo, where the number of shells thrown into the batteries was surprisingly great."

down to *l* at the bottom of the ditch, in order to allow of a communication into the ditch, which would not be exposed to an enemy's view. The embrasures for the guns at *a* and *b* have their soles made with a small depression; but the next two embrasures, being intended entirely for enfilade fire, à ricochet, when the guns have a small elevation given to them, have their soles sloping inwards rather than outwards; this gives more general stability to the mass of the parapet. This may be seen in fig. 11 *a*, which is an interior elevation, and fig. 11 *b*, which is an exterior elevation of this battery. The dimensions of the embrasures are seen fully in fig. 6, as also the platforms: the flooring of the platform is omitted in these figures in order to keep them clear and simple: figs. 17, 17 *a*, and 17 *b*, show the dimensions of the platforms in plan and sections. Fig. 11 *c* is a section taken across the battery on the embrasure *b*, with the engaged traverse seen in elevation, which is shaded in this section. (The pupil must remember that in examining fig. 11 *b*, he will have to turn the plan quite round.) The traverses in the interior elevation, fig. 11 *a*, are left unshaded; the gabions and fascines forming the interior of the parapets are shaded. The platforms having a rise in the rear of half-an-inch to each foot, will appear in elevation, as seen in fig. 11 *a*. In order to show distinctly how the traverses are made, fig. 30 is an enlarged section of the arrangement, and fig. 26 of the interior slope of the parapet. On the right of this elevated battery, the parapet is solid, and platforms for two mortars are prepared, in its rear, of the dimensions shown on the plan; an enlarged plan and section of the mortar platforms are given in figs. 14, 14 *a*, and 14 *b*. The shaded portions at *m* and *y* in the shoulders represent the best positions for the powder magazines, which may be of the sections shown in figs. 34 *b*, 35, or 36.

189. The foregoing observations will serve, in a great measure, to explain the plan, elevations, and sections of a sunken battery, for the same quantity of ordnance, shown in figs. 12, 12 *a*, 12 *b*, 12 *c*: and fig. 12, both the traverses are represented as engaged or connected with the parapet: the right traverse is made by leaving a solid block of earth, with a base of about 12 feet, and an upper surface of 10 feet, unexcavated, and of the required length of 18 feet; on this, two rows of gabions may be placed, with two tiers of fascines above them to complete the required height of traverse; that is, the solid mass of earth is 3 feet below the ground line, and the gabions and fascines 4½ feet above it. It will be observed, that in this sunken battery, the interior elevation, fig. 12 *a*, shows that there is no supporting revetment below the ground line, the soil being supposed to be sufficiently stiff to stand firmly without support. The pupil should not leave this important subject until he has mastered it, and drawn all the plans, sections, and elevations on a large scale.

190. The plan of the embrasure in the elevated battery, fig. 6, admits of alteration under certain circumstances; it is here shown as 9 feet wide at the mouth of the sole, and 11 feet at the foot of the superior slope; but should the gun be intended entirely for enfilading fire with diminished charges, the explosive effects of the charges will be less, and the sides of the embrasure may be represented by the dotted lines *a a*, and thus the mass of the parapet will become more solid and firm. The details of the plans of the elevated and sunken batteries, as shown in figs. 11 and 12, must be sought for in figs. 5 and 10, which represent them on a larger scale.——The tracing of embrasures by General Sir Charles Pasley, R.E., is as follows, see fig. 13:—at 5 feet from the neck along the line of fire raise a perpendicular, and lay off 1 feet on each

side. Lines drawn from the neck through these points give the sides of the embrasure at the bottom or sole: this makes the mouth about 6 feet wide; and at the foot of the superior slope about 8 feet wide. This tracing has evidently been adopted by Sir Charles Pasley in his practical operations, when the gun has been intended (as in most cases it is in offensive works) for a specific object, such as a steady ricochet fire with diminished charges. The less space that is taken up by the embrasure, the more solid and firm the battery becomes, and the men are the better covered. Should the gun have to traverse on its platform to take a wider range, it is necessary for the embrasure to be wider, as seen in figs. 11 and 12, where 9 feet is given to the mouth at the sole. The engineer charged with the construction of the battery must exercise his own discretion and judgment in tracing the embrasures of the dimensions suited to the objects in view.

191. A reference to figs. 32, 33, shows an embrasure provided with a musket-shot-proof shutter, or mantlet, used when an enemy is within the range of musketry, in order to protect the gunners as much as possible from the shower of musket-bullets constantly fired into the embrasures in order to silence the fire of the guns. Fig. 32 is a rear elevation, and fig. 33 a section of this mantlet.——In fig. 31, the arrangement of the gabions and sand-bags above them, as well as the genouillère (or solid part of the embrasure below the sole of it), refers to a construction that frequently arises in sieges, especially in the offensive crowning batteries on the crest of the glacis, where the depression of the sole of the embrasure is steep and rapid, in order that the guns in battery may see low down before them. The examination of figs. 25, 26, 27, 28, 29, 30, 31, 32, and 33, will acquaint the pupil with the manner in which the various field-revetments of gabions, fascines, and sand-bags, are used in batteries.

192. Should the battery be at a greater distance than 600 yards from the enemy's guns, the dimensions shown in figs. 11 and 12 may be decreased to 14 or 12 feet in the superior slope. The depth of the ditch should never exceed 6 feet in offensive works of this nature; as anything beyond this makes it very difficult to throw the soil up from the bottom of the excavation; indeed a less depth (5 feet) is more convenient: in which case, as well as for the additional earth required for the traverses, the breadth of ditch must be increased.——The height of the parapet of a battery requires to be either increased or diminished, in the cases of its being commanded by the hostile work; or the latter being commanded by it.

193. *Howitzer batteries* have usually the neck of their embrasures a little wider than long-gun batteries. All short guns in batteries, such as the old howitzers and carronades, have the disadvantage of requiring wide necks for their embrasures, and thereby exposing the gunners. The flash, and expansion of the elastic fluid, on the explosion of the charge, taking place at the neck, soon ruins the embrasures. Howitzers being fired with a little elevation, (as well as guns for ricochet,) the soles of the embrasures may, in these cases, as has been already intimated, be made with a counterslope, that is, sloping inwards; which adds something to the general stability of the mass. Howitzer and ricochet batteries may sometimes be made without embrasures to cover the gunners better, the guns at 15 feet apart, and retired from the parapet so as to fire over it. A trench may be dug between the parapet and the guns, extending on both sides of the battery, in order to check the enemy's sorties. When howitzers are fired at considerable elevations, that is, 10° or 12°, this construction is best, and gives great strength to the parapet, which can then be countersloping at top, unless a fire of musketry is likely

to be required from it, in which case the superior slope must have the usual depression to the front.

194. *Mortar batteries* have no embrasures: if exposed to a heavy fire, their superior slope may be flat at top, or even have a counterslope. Mortars are usually placed at 15 or 18 feet apart, and when fired at 45° of elevation, they are removed to a distance of 7′ 6″ from the epaulement: as the angle of elevation is decreased, the pieces are proportionally removed to a greater distance from the epaulement.

195. *To trace the battery* shown in fig. 11 (probably at dusk on the second night of the siege): required 1 non-commissioned officer and 3 privates, 1 ground square, 1 measuring tape, 1 white tracing-line or tape, 2 ten-feet rods, 1 bundle of pickets, 1 mallet. The tracing pickets and mallets to be carried in a sand-bag, and a few long pickets to mark the embrasures. A line, *a x*, should be carefully laid down in the exact direction of the object against which the battery is to be erected: if for direct fire, this line should be perpendicular to the face of the work; if for enfilade, it should be exactly parallel to the prolongation of its crest and 4 or 5 feet within it: this line, *a x*, may be about 60 feet long, and may be called the line of fire. Perpendicular to this line, *a x*, lay down the line *o p*, by means of the ground square, for the crest, and a line parallel to it, at $1\frac{1}{2}$ feet, for the foot of the interior slope of the parapet; picket down this last line, also the lines, *p m* and *o y*, in the required direction of the epaulements. Add together the breadths of the interior, superior, and exterior slopes; of the berm, and of the front slope of the ditch, in this case (1′ 6″+18′+6′+3′+3′) say 31′ 6″, and picket the line, *f h*, and the line *f l* and *h i*, at their proper distances, parallel to *o y* and *p m*. The calculation of the deblai having been previously made by the officer charged with the execution

of the work, and the dimensions of the ditch fixed accordingly, the reverse slope of the ditch must be traced in like manner, and picketed off, as the workmen will begin here to form the rough epaulement or flying-sap, *k k*. Pickets, 3 feet 6 inches long, are driven in along the line, for the foot of the interior slope of the parapet, to mark the centre of each embrasure, and mark also the necks of the embrasures, by driving in pickets at the distance of 1 foot on each side of these centre pickets: then measure off 12 feet from the sill of the embrasure perpendicular to *o p*; and on each side of the end of this 12 feet line, drive in pickets 3 feet long, (see fig. 6) to mark the width at the mouth of the embrasure: this must be done for each embrasure. As soon as the battery is traced, and the screen, *k*, finished, the diggers are placed at 4 feet apart in the ditch, and throw up the earth from the ditch upon the parapet, forming the whole into a solid mass as high as the soles of the embrasures, that is, about 2 feet 9 inches, or 3 feet high; there will then be some cover behind this bank for the builders to arrange the revetment, and prepare the embrasures, traverses, &c.

196. *Working party: tools and materials required for each gun, mortar, traverse, and epaulement, in an elevated gabion battery.*

Men. On an average, from 9 to 12 men per gun, (according to the nature of the soil,) to excavate the ditch, and to form the parapet, besides 2 sappers, and 2 assistants to revet the work.

For the extra parapet, where there are mortars or traverses, one-third more than the number required for a gun.

Extra men for each traverse, 10.

For the epaulements or shoulders; the number of men depends on the length of the epaulement.

Tools and reveting materials, according to the nature and size of the battery.

To apply this to fig. 11:—

4 guns at 15 men each, including builders .	60 men
2 mortars at 17 do. do. . . .	34
For the two traverses, and for their extra portions of parapets, 20 to 26 . . .	44
For the epaulements, 15 men for each, do. .	30
	168 men

For the siege of Bayonne (in 1813), the Duke of Wellington allowed 20 men for each embrasure, to construct the battery, platforms, magazines, and traverses in one night: 40 pieces of artillery were to be put in battery; total working party 800 men to be relieved every six hours.——*Tools.* 9 pickaxes, 15 spades or shovels for every 18 feet; for every two guns, 1 saw, 1 hatchet, 1 bill-hook, 1 field-service level, 1 six-feet rod, 3 mauls, and 3 rammers; for every three guns, 1 lantern, 2 pounds of candles; in all, for 4 guns and 2 mortars, as in fig. 44, with two epaulements, 74 picks, 130 shovels, 3 saws, 3 hatchets, 3 bill-hooks, 3 field-service levels, 6 six-feet rods, 9 mauls, 9 rammers, 2 lanterns, and 2 bundles of matches.——*Reveting materials.* For battery, fig. 11, there is 116 feet of parapet on *o p;* 20 feet for the two epaulements,=136 feet; now, if the gabions be 2 feet in diameter, and 3 feet high, two tiers of gabions will be required for every two feet (as in fig. 30), in all 136 gabions: allow 3 gabions for each cheek of an embrasure, in addition to the 1 at the neck (see fig. 5); then 4 embrasures×6=24 gabions; the gabionade, *k k*, on the front and epaulements is equal to 236 feet, requiring 118 gabions. Two traverses, requiring 64 gabions. Fascines, 18 feet long, 16 for the parapet and epaulements; 8 for the 2 traverses; and 8 for the 4 embrasures; fascine pickets,

1 bundle of 50 to 6 fascines; some spare bundles of gads, and a roll of measuring tape.*

197. *The works of a siege executed in sand-bags*, has considerable advantage; for *it saves men and time.* There is no battery that cannot be commenced and finished in one night, if the bags have been filled and prepared beforehand: and this can nearly always be done; because the batteries ought to be preceded and protected by saps, during the execution of which there is always time to fill the sand-bags. *A flying-sap ought to be executed in a quarter of an hour*, so as to cover the workmen who may have to excavate the trench in rear, when the ground admits of it, and who have to raise and thicken the parapet. In order to employ sand-bags with the utmost efficiency, it is necessary that they should be made of strong canvass and tarred, of exactly the same dimensions; and that they may be easily and quickly laid for parapets, loopholes, embrasures, &c., the sappers should be exercised in filling them; in forming themselves into squads, in order to work with the utmost despatch; in practising flying and full saps in sand-bags: upon the perfection of all which details the success of the operations may often depend.†

* It is not always necessary to revet the epaulements of a battery; they may be left with their interior slope having a base, of one half or more of the height, as the soil may be found capable of standing for the time the battery may be required. It will be good practice for a pupil to calculate the exact quantity of earth required for this battery, by the process given in *Appendix* [*A*]; including the traverses, epaulements, &c., and deducting the embrasures: then to regulate the size of the ditch accordingly, supposing cases where the depth is to be 5, 5½, and 6 feet; and draw out the figures on a large scale with tables of material, number of men, and time required for the work.

† At the siege of Gerona by the French, in 1809, there was a remarkable instance of the rapidity with which a battery was formed by sand-bags. On the 2nd of July, during a night of rain, a battery

198. *Platforms for guns.* To enable a gun to be worked with ease, expedition, and accuracy, it must be placed on a platform. In permanent fortification, platforms are sometimes made of stone, but in field-works they are always of timber: they are composed of beams or sleepers covered over with a flooring or deck. For guns, the platforms are laid with a slight rise to the rear (about half an inch to a foot); and as the platforms are usually 15 feet long, there is a rise of $7\frac{1}{2}$ inches from front to rear. —— See figs. 17, 17 *a*, 17 *b*, Plate VIII, for the plan and sections of a gun or howitzer platform. Materials required, as follows (of fir):—

5 Sleepers, each 15 feet long; 5″ square . .	weight, depending on the nature of the wood; about $13\frac{1}{4}$ cwt.
20 Planks, each $10\frac{1}{2}$ feet long: 9″ broad & 2″ thick	
2 Ribbands, each 15 feet long and 4″ square .	
10 Rack-sticks and lashings, or iron bolts . .	

for 20 guns was formed in eight hours upon a rocky ground, having a height of 7 feet 6 inches, and a thickness of parapet 16 of feet 6 inches, the embrasures being at a distance of 19 feet 9 inches from centre to centre. 80,000 sand-bags had been filled beforehand, and arranged in five separate heaps of 16,000 each, placed in hollows hid or screened from the view of the place, at a distance from 100 yards to 50 yards from the site of the battery. Three thousand workmen were allotted to carry the bags, and divided between the five depôts. The operation commenced at 9 P.M.: the men felt the necessity of a prompt execution, and each carried two and even three bags: at 5 A.M. on the following morning, the 20 pieces, under cover of this beautiful battery, commenced their fire, to the astonishment of the besieged.——In the French siege of Constantine, in 1837, batteries and saps were formed of sand-bags, in consequence of the rocky nature of the soil, with even a greater rapidity than the like work could have been executed in the ordinary manner by gabions and fascines.——On naked rocky ground, a deficiency in sand-bags will prove to be a serious detriment. In the attack of hill forts in India, a large supply of sand-bags should be provided: the author remembers that the most efficient battery against the hill fort of Singhur, in 1818, near Poonah, was of sand-bags, and beautifully made.

The sleepers must be well embedded in cuts or trenches, and firmly fixed or pinned into the earth, then covered with the planks, and finally completed with the two rib-bands and five rack-lashings on each side. It will be observed that the form of the platform is rectangular 15′ × 10′; differing from that in permanent fortification, which spreads or splays to the rear: this latter form is best suited for traversing guns to the extreme opening of the embrasure: but if the field platform were made of this form, splaying to the rear, the planks would all differ from each other in length; and the sleepers underneath would also have to follow this form, and spread out fanlike, to sustain the planks. Now, as battery platforms in a siege are almost always laid at night by a very indistinct light, and sometimes under fire, such an arrangement would be very difficult, if not impracticable: but when of a rectangular form, as soon as the sleepers are properly laid, the boards being all of the same size, the first that comes to hand will suit, and the platform is easily and quickly laid. Moreover, as guns in sieges have a specific duty to perform, and are placed in such a position as scarcely to require traversing right or left above two or three degrees, the rectangular form is as good as the other for all the purposes required.*

199. There are three modes of fastening the flooring or deck to the sleepers—by screws, spikes, or rack-lashings.

* *Colonel Alderson's platform.* Colonel Alderson, of the Royal Engineers, has introduced a platform for guns and mortars different from any of the above, and which has been fully tested by the Royal Artillery at Woolwich. It has this great advantage, that the whole of the platform is made of timber of the same dimensions throughout; that is, the sleepers and the deck all consist of light beams of wood, each 9 feet long, 5 inches wide, and $3\frac{1}{2}$ inches thick, weighing 37 lbs. (which a man can carry, with his arms and ammunition). These beams fit into each other by dowel pins, having suitable holes. The weight of this platform for guns (when 15 feet long and 9 feet wide), is 15 cwt. 2 qrs. and 14 lbs. It can easily be extended from 15 to 18

It is evident that the rack-lashings must be arranged in their proper places when the two outer sleepers are first laid in their grooves or trenches in the earth. For carrying this platform, 2 men are required for each sleeper, 1 for each plank and ribband. The non-commissioned officer carries the rack-lashings. This platform may be laid down in an hour by expert men, and may be dismantled in a few minutes.

200. *Platforms for mortars.* (Figs. 14, 14 *a*, 14 *b*, Plate VIII.) Materials required (of fir), to be laid perfectly horizontal.

7 Sleepers; 5 of which are laid longitudinally, and 2 transversely, underneath the 5; all well embedded in trenches in the ground; each sleeper 7 feet 6 inches long and 6 inches square; 8 planks, 6 feet 6 inches long, 11 ¼ inches broad, and 4 inches thick	weight depending on the nature of the wood; about 9 cwt.
2 Ribbands, 7 ft. 6 inches long, and 4 in. square	
10 Rack-sticks and lashings	

201. As the recoil of a mortar fired at 45° of elevation is at this angle on the platform, it is necessary to make a mortar platform stronger than a gun platform; hence 7 sleepers are used, as stated above, instead of 5, and the scantling of the sleepers and flooring is greater in the mortar

feet in length, by the simple addition of the small beams; which is very advantageous; as, in firing 32-pounders with service charges, the recoil almost invariably carries the gun-carriage beyond the 15 feet length of ordinary platforms. The strength and stability of this platform is very great: it is laid with great ease and quietness, and although its weight is somewhat greater than the ordinary platform, it is more than made up by its advantages; and it is equally available for mortars as for guns or howitzers. (*From the "Aide Memoire."*)

than in the gun platform.——1 Non-commissioned officer and 17 men can carry the platform. Time required for laying or dismantling, the same as a gun platform.

202. *The Madras platform.* (See figs. 18 and 18 *a*, for the plan and side elevation.) It consists of a strong frame-work made as follows—

203. Two side pieces, *a a*, are each 12′ 6″ long; and 9″×4″.——1 Fore transom, *f*, 6′ 6″ long, and 6′ square.——2 Hind transoms, *h* and *i*, each 6′ 3″ long, 12″ wide, and 4″ thick.——2 Trail-pieces, *b*, 12′ 6″, and 4″ square.——3 Sleepers, s=8ft. 3in. : s'=10ft. : s''=10ft. and all 6 inches square.——2 Wedges for the rear, to run the wheels of the gun upon the side pieces.——Iron bolts, with nuts and screws, fasten the transoms to the side pieces and the trail-piece.——The trail-piece is to receive and guide the trail of the carriage in recoiling, and thus keep the wheels in their places on the side pieces.——Weight of Madras platform, about 8 cwt. 2 qrs. 16 lbs.

The front transom is fixed firmly at the foot of the parapet, and pinned down; the 3 sleepers are also firmly pinned down. The whole platform has a rise to the rear of 8 or 10 inches. The framed work is easily moved by hand-spikes, so as to slide over the 3 fixed sleepers, and thus to traverse the gun as much as may be required. 24-pounders have been tried with success on the Madras platform.

204. *Field powder magazines* are made of various shapes and dimensions. General Sir Charles Pasley's are of two kinds: a rectangular section, as seen in fig. 35, or of a triangular section, as in fig. 34 *b*. A plan of one of these magazines is seen in fig. 34; this may be made in rear of the centre of a battery: to commence this, after tracing it distinctly on the ground and setting up the profiles,

the space *e f h g*, is excavated for the frame-work for the magazine, sections of which are seen in figs. 34 *a* and 34 *b*: ramps lead from the battery into the ditch or trench in rear of and parallel to *g h*: having little cesspools, *a a*: the bottom of the magazine may be about 3 feet below the ground line: the side, *e f*, lined with planks and fascines, as seen in figs. 34 *a* and 34 *b*. A smaller frame in fig. 34, as the doorway, leading into the magazine. The sloping side beams, from *g h*, to *e f*, are covered with stout fascines: one row or tier is seen in fig. 34 *b*: but 2 tiers may be used, not only as a good covering but from their elasticity when splinters of shells fall on the battery. Fig. 35 holds more powder than the triangular section, but the latter resists the fall of small shells, or splinters of shells, better than the rectangular form. Fig. 36 is a section of two strong splinter-proof timbers,* say 8 or 9 feet long, and 9″ or 12″ square, resting on sleepers, and giving an interior space, of about the dimensions seen in the figure, covered with one or two tiers of fascines, and over them 3 or 4 feet of dung or stiff earth; this simple construction would answer in many cases. On the whole, it is considered better to have two small magazines in a battery, made of very stout mining cases, and constructed in the epaulements, as at *m* and *y*, fig. 11, than one larger one, as in fig. 34.†

* This name is given, because the arrangement is merely intended to be proof against the splinters of bursting shells; a heavy shell falling upon the contrivances now referred to, would crush them in; but being very small objects, this evil rarely occurs.

† Sir John Jones makes the following remark on this subject: "Splinter-proof timbers for magazines were cut 12 feet in length, and from 8 to 10 inches in breadth and thickness, and were placed against an epaulement, or parapet, at an angle, making the base equal to half the height. They were then covered with a tarpaulin, extending well over the top of the epaulement, upon which were laid one or two rows of filled sand-bags, so as to prevent the possibility of the tarpaulin being cut by splinters of shells. A second tarpaulin

was usually thrown over the exterior in rainy weather. On this construction, the magazines were found to be perfectly dry, and sufficiently spacious, and of the strength no doubt can remain, as the sandbag covering was frequently knocked off by large shells, and in no instance were the splinter-proofs broken.

"The best situations for magazines are on the flanks of the batteries. Nothing can be worse than to place them in rear of the centre of a battery, as then every cartridge has to be carried along the most exposed and dangerous part of the battery, and the number of accidents and casualties which arise therefrom is very great indeed. The artillery always preferred to have two magazines formed, rather than to have one exceeding ten or twelve feet in length: when two were made, they were placed, one on either flank, a situation which was found to answer extremely well, for the magazines of batteries constructed in advance of a parallel, was at the extremity of a cut made perpendicularly through the parapet of the communication from the parallel, at ten or twelve yards before arriving at the battery. The level of the floor of the magazine was then kept as nearly on the level of the approach as would admit of its being drained; and the foot of the splinter-proof timber was sunk twelve or fourteen inches under it. In this situation an accidental explosion of the magazine will not injure the battery."

CHAPTER VIII.

ON SAPPING AND MINING.

205. *Sapping*, see figs. 71 to 79, Plate IX, is a mode of constructing trenches and parapets under a *musketry* fire. The sappers, or engineer soldiers, must be well instructed in their business: it is a slow operation, as the work cannot proceed at a quicker rate than what one man can dig at a time. For this duty, the sappers are told off into squads or brigades of four men each: the man at the head of the squad is the first sapper, and they are numbered 1, 2, 3, 4. The head of the trench, which they dig, is covered by a sap-roller (paragraph 153): and on the flank whence the fire comes, the sappers are protected by a line of gabions filled with earth. Fig. 72, shows a plan and section of a single sap, with the work of each sapper numbered in the section: the sap-roller is pushed on by the head sapper, assisted by No. 2, by means of forks having long handles. The first sapper cuts the trench marked No. 1 in the section, making it 18 inches wide and 18 inches deep: No. 1 also places each successive gabion: he works on his knees, taking care to leave a banquette of 18 inches between his trench and the row of gabions: he works in a length of 5 feet, with which the following sapper does not interfere. No. 1 is very careful not to allow his body to pass the gabion last placed till he has filled it with earth, and placed a sap-fascine or a couple of sand-bags in the hollow between the two advanced gabions, so as to have a musket-shot proof cover behind which to continue his work: the leading sapper thus occupies the most dangerous as well as

the most laborious post, which each of the squad takes in succession.——No. 2 works on his knees, and excavates the trench marked II in the plan and 2 in the section: to equalize the work, his trench is 20 inches wide and 18 inches deep, having a length of 5 feet.——No. 3 follows No. 2, deepening the trench to 3 feet, marked III in fig. 72, and 3 in the section underneath: and No. 4 completes the trench by enlarging its breadth 10 inches, and deepening it to 3 feet, marked IV in the plan and 4 in the section: the earth excavated by the squad is first put into the gabions and afterwards thrown beyond them, so as to form the rough parapet seen in the plan and section. Working parties follow the sappers, and complete the trench to any dimensions that may be required.——In sapping, or in using gabions as a revetment, &c., they should always have a little slope outwards towards the parapet, of about one quarter their height; for, if placed quite upright, any swelling of the fresh earth of the parapet from rain, would throw them down inwards. By examining figs. 71, 72, and 73, the plan, section, and elevations of a single sap, the pupil will become fully acquainted with all its details: the sap-fagots need only be used between the gabions where there is no earth beyond them.

206. The time occupied in constructing 10 feet of sap, in the manner just described, is about one hour; but if, during the night, the fire from the place slackens, portions of sap may be pushed on more rapidly by placing several gabions at a time, and filling them simultaneously: when this is done, it is called the *flying-sap*.

207. Approaches by sap are usually carried along the capitals of attacked works, in a zigzag direction; see fig. 120, Plate VII: the direction of each successive zigzag is such as to be clear of enfilade from the place, hence their parapets run obliquely to the place; but when the saps

draw near, these zigzags become so multiplied, and the angles between them so acute, that it saves time in many cases to carry on a double direct sap towards the place. Thus when 100 yards of zigzag does not carry the approaches so much as 32 yards in advance, the double sap should be adopted. Two brigades of sappers are employed on it at a time, each covered in front by a sap-roller, fig. 74, Plate IX; the gabions of the two squads are usually 12 feet 6 inches asunder: the intervals between the sap-rollers (about 2 feet) being covered by a short sap-roller. This double sap is therefore a mode of advancing against a musketry fire in the front and on the flanks. Should the sap be liable to be enfiladed or raked, it must be traversed; that is, instead of being carried on in a straight line, the squads of sappers must work round solid dies of earth, as in fig. 74, which form the traverses.

208. In the event of sapping under a commanding situation, it may become necessary to blind * the sap; that is, to set up strong frames to be covered at top with fascines, sand-bags, and earth; in such a case, the sap should be narrowed as much as possible.

209. Fig. 75 shows a plan, and fig. 79 a longitudinal section of a double sap with 4 sap-rollers in front, worked by 3 brigades of sappers; first proposed by Colonel Jebb, R.E. Sections and elevations of this sap taken on the lines C D, F E, and G H, are shown in figs. 76, 77, 78: the work of each brigade is the same as in the single sap: an inspection of these figures shows the progress of the sap and its details; the unshaded gabions, in the two traverses near the head of the sap, indicate that they are not filled with

* The terms blind, or blinding, a work, is hooding or covering it over. Thus guns and mortars are frequently covered over with strong timber or blind frames and earth. The splinter-proofs already described in paragraph 204 may be called blinded cover.

earth, and as they can be easily removed, will allow a sapper to creep in to keep up a communication. As the three squads work steadily in advance, others following them, lay out and complete the traverses, for which purpose part of the excavated work must be filled in again: this is a loss of time, but it is more than compensated for by security and general expedition of the sap. In fig. 74, the sappers have to wheel the great unwieldy sap-rollers in working round a solid die of earth in order to form a traverse, which is a dangerous process, and so exposes the men that expert riflemen are sure to find fatal openings: but in fig. 75, the sap-rollers move steadily on in one line, and thus keep the men well covered at work.——In order to commence such a sap from a parallel, the sap-rollers are carefully passed over the top of the parapet of the parallel by means of beams and ropes. Suppose the four sap-rollers of this sap to be thus passed over the parapet of the parallel, the three brigades of sappers then commence their respective work: the right brigade remove gabions 1 and 2, and No. 1 sapper proceeds with his excavation; the others complete the traverse P, assisted by the centre brigade, who have removed gabion 3; and No. 1 sapper of this brigade goes on with his excavation. The left brigade remove gabions 4 and 5, and proceed with their regular work; first clearing away the parapet of the parallel. Sappers No. 3 and 4 of the right brigade, afterwards fill in the excavation of No. 1 with fascines, from *a* to *b*, to make a good footing for the gabions 1 and 2, which they replace, and complete traverse P.——The right, centre, and left brigades work steadily and equally in advance: the gabions at 3 are removed, and the sap completed in this part.——Gabions 6, 7, 8, 9, 10, are placed so as to protect the workmen in the branches Q and O: these gabions are removed in due time as the sap proceeds. Similar cover is used in each successive branch

N, M, L, K, &c. This is seen at the head of the sap, from the sap-rollers to the second traverse: those in the rear being completed, have this centre line of gabions removed. ——In addition to the three brigades of sappers, a working party from the line is required to clear the branches Q, O, N, &c., and throw the earth over the gabions for the exterior parapet——*Materials required.* 28 feet from the centre of one traverse to the centre of the next, giving 28 gabions for the two sides, and for each traverse 12 gabions. ——*Fascines.* Two rows on each side, or about 6 fascines of 18 feet in length. Fascines for the traverses, about 4 fascines for each. Also fascines for filling in No 1 sapper's work through the traverses. Four sap-rollers. Two or three dozen of sand-bags.——It may be observed that there is no banquette on the outer side of the traverses, so that an enemy penetrating from the front could not use the traverses as the defenders can from their banquettes.——Were it necessary to blind this sap, ten or eleven feet bearing between the uprights would suffice to do it.

210. *Military mining*, is what may be termed superficial mining when compared with civil mining. The military miner works through the more recent formation of earths and lands, which from their little tenacity he has to support as he advances with linings of wood or masonry; it is in the adjustment and fittings of these linings that the chief art of the military miner consists; and the object is to reach a point where it is desirable to place a charge of gunpowder for explosion. Plate IX, figs. 49 to 57.

211. Charges of gunpowder exploded under an enemy's work are used to destroy it. In many cases it is a very desirable proceeding, when cover can be obtained sufficiently near to permit galleries being driven under the part to be destroyed or breached; and when the nature of the soil is such as to admit of galleries being constructed under ground.

——In defending works, small mines placed under the path that an assailant must take in his attack, will do good service, if they can be fired when he is exactly over them; but there is great difficulty in managing this. They are liable to be fired too soon or too late, from haste or from delay. The hose or fuse from the point of firing to the charge takes some seconds to burn; and it may be easily conceived how the time may be miscalculated that an enemy will take (when seen advancing) to be exactly over the required point. It is desirable to have some obstacle requiring a certain time for an enemy to overcome, such as an abattis in a sunken unseen ditch, &c., and the mine under this, or a palisading, stockade, trap-holes, &c., so as not to fire the charge until he actually reaches the obstacle, and is occupied in forcing it.

212. The application of gunpowder in blowing open gateways, stockades, destroying buildings, walls, &c., may be successfully employed in the attack of villages, posts, and field-works: and when there is no time for the construction of regular shafts and galleries, *large* charges laid against obstacles will succeed in doing mischief.

213. The common mode of proceeding is, to sink a a square shaft or well to the necessary depth, and from the bottom of this shaft to drive out a gallery of the length required, so as to lodge a sufficient charge of gunpowder in a chamber at its extremity, which by its explosion will destroy the enemy's work.——Fig. 51, Plate IX, is a vertical section of a shaft and gallery: *f d* is the shaft, and *d h* the gallery; *c* is the chamber to receive the charge of powder. This is seen also in plan in fig. 52, where the chamber, *c*, is shown on one side of gallery, that when the explosion takes place, the force of the elastic fluid shall not be exerted immediately in the line of the gallery. In the plan, the top of the gallery is bared of the earth that would

be above it, in order to show the pupil the arrangement of the gallery cases.——Shafts and galleries are lined with cases made of timber to prevent the soil from breaking in, and, when complete, the charge is lodged in the chamber *c*; a powder-hose (formed by sewing a tape, three-quarters of an inch wide together, along its whole length, and filled with fine gunpowder,) is enclosed in a trough, made of two battens of wood hollowed or grooved in their centre. The hose, or train, thus prepared and protected by its wooden trough or case, is conveyed safely from the charge through the gallery and shaft to the point from which it is to be fired: as from *c* to *d* and *f*, fig. 51.*

214. In fig. 51, suppose the depth of the shaft, *f d*, to be 12 feet below the ground line, *f*, and that the gallery runs parallel to the surface of the ground: then the distance from the charge, *c*, to the *nearest* surface of the ground, is called *the line of least resistance.* The effect of the charge upon the surrounding ground depends upon the quantity of powder lodged in the chamber, and certain rules are given to guide officers in such cases, so that they may know what quantity of powder to use; the line of least resistance is generally expressed by the letters, L I. R.

* There is a substitute for the powder-hose used in the service on some occasions: it is called *Bickford's patent fuse;* being a very small tube of gunpowder, *served* round with tarred twine, and the whole pitched over: it is procured in coils like small rope, and keeps very well; it is not injured by damp, and will even burn (when well made) under water. When it can be had, it should be used in preference to the powder-hose when the charges are not deeply buried in the earth: it burns regularly at the rate of 12 feet in 5 minutes: hence the chief objection to it is the time it takes to burn: and a serious objection this is, as in a gallery requiring 24 feet of this fuse, 10 minutes would elapse before the explosion after lighting the hose; whereas the common hose burns very rapidly. Bickford's fuse may be used with advantage in firing bags of gunpowder intended to burst open gates, barriers, stockades, &c.: 2 or 3 feet of it will give time for the man who lights it to escape.

215. As soon as the charge is lodged in the chamber, the hose trough properly fixed, and the mining cases withdrawn, the chamber is blocked up with earth to a length equal to once and a half the line of least resistance, in order to prevent the effects of the explosion finding vent through the gallery: this blocking up is called *tamping*.

216. When the charge is exploded, the crater or funnel formed thereby depends upon the amount of the charge: if it be sufficient to form a moderate sized crater, having a diameter at top equal to twice the length of the the line of least resistance, it is called a *two-lined charge*, and a *two-lined crater*: increased charges will give craters having diameters equal to three, four, five, and six times the lines of least resistance.——A two-lined crater, in common soil, is generally produced by a charge of gunpowder found by cubing the line of least resistance, and dividing by 9: thus, if the line of least resistance be 12 feet, then $12^3 = 1728 \div 9 = 191$ lbs. nearly.

217. There are two modes of arranging the timber supports for shafts and galleries: the old method is by placing square or rectangular frames at every 3 or 4 feet apart, and by lining the spaces between them with strong planks or *sheeting*. If the soil be loose, these planks are placed close to each other; if stiff, two planks on each side of the gallery or shaft will suffice, although the top of the gallery must always be lined throughout. But the use of frames and sheeting have given place to the more rapid and perfect method of casing, which can be done at the rate of 1 foot an hour in great galleries, and $1\frac{1}{2}$ feet an hour in common galleries, which is nearly double as quick as working with frames and sheeting.——This approved mode of lining the galleries and shafts, introduced by General Sir Charles Pasley, K.C.B., Royal Engineers, is by means of a succession of cases, formed and fixed as in figs. 49 and 50.

Each case is composed of four pieces of plank, about 2 or 3 inches thick, and 10 or 12 inches wide: the two side pieces have tenons to fit into the mortises, made in the top and bottom pieces. To prevent these pieces of plank from splitting, an iron rivet of $\frac{3}{8}$-inch iron rod is driven through the middle thickness of the wood, at $4\frac{1}{2}$ inches from each end (shown by dotted lines in fig. 49). The lengths of the different pieces of a case depend upon the size of the required shaft and gallery. Fig. 50 shows the different pieces of the case of fig. 49 fitted into each other (the dots in fig. 50 are the heads of the iron rods): the thickness of the timber being seen in fig. 50, and the width of it in fig. 49. Let it be supposed in this figure, that the planks of the cases are 10 inches wide and 2 thick; that the shaft *f d*, fig. 51, is 12 feet deep, with an interior capacity of 4 feet square: also, that the gallery, *d h*, is 17 feet 6 inches in length, and has a clear interior capacity of 4′ 6″ high by 3′ wide.

218. *To sink a shaft.* See figs. 51 and 52. This is a square shaft: each of the four pieces are 4′ 4″ long: the mortises and tenons are each 2″ long by 3″ wide: hence there is a clear interior space of 4 feet when the pieces are fitted into each other. Let the planks be 10 inches wide and 2 inches thick.——To sink the shaft: excavate to the extent of the exterior size of the frame, and to a depth of 10 inches (or its breadth), and place the first case in it. In placing the second case under the first, excavate to the extent of the interior size of the case, and 10 inches in depth (but deeper in the middle of the shaft for the convenience of the man at work); then cut out a space equal to the thickness of one of the pieces having mortises, and fix it in its place; do the same with the other short mortised piece exactly opposite to the first, at the required distance of 4 feet; then prepare the place for a tenoned piece, in

fixing which it becomes necessary to cut away an additional slope of earth at one end so as to push the end of the tenon beyond its proper position, and then to draw it back in order to get both tenons into the mortises. Thus a few inches of earth is cut away from one end beyond what is actually occupied by the case; and each side is thus adjusted.—— Each successive case is thus fixed by separate pieces, case under case, until the required depth be obtained.

219. *To drive a gallery with General Sir Charles Pasley's cases.* (See fig. 51.) When the shaft is completed, a frame composed of 4 pieces, like a door frame (at *d*), is set up on that side of the shaft from whence the gallery is to be commenced, having its sill sunk below the level of the floor of the proposed gallery. This frame is taken down the shaft in pieces, and put together so as just to fit in between the sides of the shaft: its height in the clear must give good space for the gallery. The exterior dimensions of this frame (in figs. 51 and 52) would be 5′ 8″ high by 4′ wide; the interior dimensions would be 4′ 10″ by 3′ 4″ wide; the gallery casing being of the dimensions noted in figs. 51 and 52. The cap and ground-sills of this frame are shaded in fig. 51.——The undermost end or side pieces of all the lowest cases must be removed from that side of the shaft against which this frame is set up, until the earth is laid bare to admit of the excavation for the proposed gallery. In this operation, the lowest piece of all must be first removed, then the next above it; the others may be taken away after the frame is fixed. This frame is to prevent the sides of the shaft collapsing after the pieces have been removed for driving the gallery.——Suppose the gallery to be 4′ 6″ high by 3′ wide in the clear: the pieces of the cases are prepared exactly in the same way as are those of the shaft; supposing them to be turned into each other, the mortises fitted into the tenons.——To drive the gallery, *d h*,

fig. 51, the cases are set up in succession as the excavation proceeds, so that there is never more than 10 or 12 inches of unsupported earth opened at a time: the mortised pieces form the ground and cap-sills; the tenoned pieces, the sides or stanchions. A little management is required in adjusting the cap or top sill on the stanchions; the mortise of one end of the cap must first be fitted to the tenon of the stanchion; after which it becomes necessary either to raise the other end of the cap, or to push out the end of the stanchion about two inches beyond its proper position, so as to fit the tenon into the mortise: a little wedging behind the vacant part left after the fitting is desirable.

220. The following table gives the names and dimensions of galleries and branches employed in mining:—

NAME AND DESCRIPTION OF GALLERY OR BRANCH.	DIMENSIONS IN THE CLEAR. HEIGHT. feet.	in.		WIDTH. feet.	in.
1. Great gallery	6	6	×	7	0
2. Principal gallery . . .	6	6	×	3	9
3. Common gallery . . .	4	6	×	3	0
4. Great branch	3	6	×	2	6
5. Small branch	2	6	×	2	0

No. 1 is for descent into ditches and the passage of cannon.

2 ditto ditto and passage of troops, two deep.

3 large enough for the general purposes of attack; and allows the miner a free change of posture, and to work on both knees or on one knee.

4 and 5 too small to work in for a greater distance than 10 or 12 feet.

221. *Great gallery* cases are stronger than those for smaller galleries, see fig. 53: the stanchions are without tenons at their lower ends, which are kept in their places by cleats two inches thick, nailed on to the sills: the mortises in

the cap-sills need not be more than 2″ deep. In driving great galleries in loose soil, it becomes necessary to support the top sill whilst the miner excavates the ground for the ground-sill and stanchions. For this purpose, two upright pieces of timber carrying a cross piece, as seen at *r*, in fig. 53, are used; the upper part rests on the sill of the frame already placed, and is steadied by being wedged up: the cross piece is 2 feet long, and the part that projects in advance is higher than the rear part in order to support the top sill somewhat higher than its final level. The rear part is braced by a piece of iron to the upright; these are called crutches, and are seen in application in the great gallery, fig. 54.

222. In working with cases, the direction of a gallery may be easily and gradually changed, as seen in fig. 55; if the soil is good, the intervals which occur between the cases may be left open; if bad, they may be filled in with small pieces of wood.——When it is necessary to break out from the side of a gallery, in a direction perpendicular or oblique to it, the requisite number of cases must be removed and the roof of the interval lined with pieces of board extending across and supported on the extreme cases (see fig. 56). If the soil be bad, the stanchions only from the side whence the gallery is to proceed, need be removed, and the intervening cap-sills can be supported, as in fig. 57; but the method has the inconvenience of lowering the head-way.

223. The cases are useful for a great variety of purposes, and are extremely handy: the gallery of descent into the ditch, indicated at fig. 46, and communicating with the covered caponier; also the reverse gallery L in fig. 47, may all be made of these cases, the plank being more or less thick according to circumstances. A passage through a parapet may be supported by mining cases. Field powder-magazines also may be made in batteries or field redoubts, with these cases.

224. Shafts are chiefly used for hasty explosions; when it becomes necessary to lodge a charge at a given depth, a hose is led from it; the shaft is tamped; and the charge exploded, for the purpose of creating a great crater and throwing down some obstacle, or crushing in some gallery within the sphere of the action of the gunpowder.—— Shafts constructed for hasty explosions very rarely need to be lined with cases; and if made circular the soil stands better than when square or rectangular.

225. To drive a gallery from the bottom of the shaft, as seen in fig. 51, involves some danger to the miners at work, who cannot, in case of accident, or in the case of an enemy getting to the top of the shaft and throwing down shells, smoke-balls, &c., easily escape: whereas, in a gallery driven obliquely, as in fig. 54, the miners can get out more readily than they can by the rope-ladders of a shaft.

226. *Oblique or descending gallery*, as in fig. 122, Plate VII, 7′ wide by 6′6″ high; is used in important sieges, through which artillery can pass for operations to be carried on within the ditches. The timbers of the mining cases are in this great gallery made of larger dimensions, especially the cap-sills, which should be 4″ or 5″ thick, in order to sustain the great weight of earth above them, similar to what is seen in figs. 53 and 54, Plate IX.—— These descending galleries (fig. 122, Plate VII,) have usually a base, *a b*, about four times greater than their depth, *a c*. The cases are here shown as perpendicular to the general slope, *b c*: this gives a smooth regular slope to the bottom of the gallery, as the ground-sills are then all in the same line, and the cases are amply strong enough to sustain all the pressure upon them: were the cases made vertical, the bottom of the gallery would be in a succession of little steps; moreover, the required depression of the gallery is more correctly maintained in driving or forming

it, when the cases are placed as in fig. 122; for if the three or four first cases be laid exactly in the proper line, the rest are readily adjusted, until a change of direction becomes necessary.

227. *Ventilating and lighting galleries of mine.* In the field engineer department at Chatham, General Sir C. Pasley introduced a method of ventilating galleries of any length, by forcing air from a pair of bellows, made of a cylinder of pliable leather, into a long pipe which is conveyed to the head of the gallery: the bellows is about a foot in diameter and a foot in depth, having a circular wooden top and bottom: the air enters by a valve in the wooden bottom, and is forced into a pipe attached to one side: to this pipe, others of leather, and from three to five feet in length, can be fixed on successively, having tin tubes at each end to fit tightly into each other: these pipes are about an inch and a half in diameter; and, being always led to the head of the gallery, fresh air is pumped in continually from the bellows, which is worked at the entrance of the gallery or shaft.——All mines require ventilation and light when in progress. Experience has shown that candles will not burn in small and confined galleries from the want of air, as it becomes exhausted by the miners' breathing, unless it is supplied by artificial means.——As regards light, mirrors may be advantageously used in the day time to reflect a gleam of sunshine from the top of a shaft to a mirror at the bottom, which last again reflects it down the entire length of the gallery. But as mining work progresses by night as well as by day, and should be independent also of the state of the weather, candles are frequently necessary; and both with a view to their burning brightly, and to the health and comfort of the miners, fresh air requires to be forced into the gallery: this, indeed, is so indispensable that no galleries could be ex-

tended without it, and the common double hand-bellows, used by smiths in India, have been found preferable in India to all other contrivances; because one man seated between two of these bellows on the ground, suffices to keep the gallery well ventilated, whilst hidden from observation. A bellows of this kind is always procurable in India from the native artificers accompanying the siege train: or it may be formed, for temporary purposes, by taking a raw sheep's hide tied at the four feet, with two pieces of flat sticks secured along the opposite edges of the longitudinal cut along the belly, leaving the neck to be made fast to the tube or hose that conveys the air to the gallery. Two of such bellows should be simultaneously used, to be worked alternately by each hand. The leather skin should open as the hand is lifted up, and, as pressed down again, the hand should close it. In this simple way an abundant supply of pure air is constantly supplied to the very extremity of the gallery; care of course being taken that the hose or tube which conveys it be not trodden on or crushed; for which purpose it should be protected with casing along the corner of the shaft or gallery. If tin tubes are procurable, in lengths, they form excellent air tubes, and they should be added to extend the ventilation as the gallery advances.——It is proper to commence ventilation by bellows, when a gallery has attained the length of 50 feet; for although at that distance the lives of the miners are not exposed to any risk from foul air, yet the atmosphere, so far from the mouth of the gallery, is very impure.——There should be as few lights as possible in a mine, in order to avoid consuming the pure air; and, when practicable, they should be placed above the level of the heads of the men.——One candle should be at the head of the gallery, and the next at least 50 feet in rear of it, when the gallery is straight and of that length; and

when the gallery is not straight, a light is required at every second angle or turn, placed so as to light both ways.

228. Most rigid rules are required to regulate the loading of mines. It should be conducted entirely by the officer on duty. The size of the chamber, the dimensions of the powder-box, the length of hose, the quantity of powder necessary to fill it, the length of the casing-tube, the quantity of portfire and slow-match, the safety lantern, &c., should all receive his full attention. Too much care cannot be exercised in every detail. The powder-hose must be made of the best materials, most firmly stitched, so as not to allow any powder to escape, either in conveying it to the mine, or in laying it; otherwise the most fearful accidents may happen. Again, in placing the powder in the hose, the utmost care is necessary to fill it properly, so that, on the one hand, it shall not be made to contain so much powder as to render it liable to burst; or, on the other, that however handled and laid, there may be no part of the tube without its due proportion of powder.—— All the persons employed in the loading to be without shoes, or they should have worsted shoes or stockings on; the lights to be all removed, and all the men ordered out of the gallery except those employed in loading. —— The greatest attention is necessary to secure the end of the hose or fuse within the box or bag. If a box be used, the end of the hose should be passed through a hole on the top of the box, and a wooden skewer run through it, to prevent its being drawn out accidentally: the end of the hose should be sewed up to prevent its wasting powder. If the charge be conveyed in a truck, it should have copper fastenings; wooden wheels with copper rims. The non-commissioned officer of the mine should advance with the charge, followed by the officer, at a distance of 20 feet, carrying a strong

reflecting lamp: on reaching the chamber, the officer hands the lamp to his assistant, and proceeds to direct the placing of the charge and the laying of the hose: the latter must be secured in a casing-tube, the lid of which is pegged down, and immediately afterwards covered over with 6 inches of mould: in doing this a copper shovel should be used.

229. In order to obtain materials for tamping the mines, branches may be driven right and left of the main gallery, and the earth required wheeled forward.——In tamping, half-dried mud-bricks have been used: a very small gallery of this kind, of 25 feet in length, occupied 2 hours and 48 minutes in tamping. Two or three feet an hour is the full extent that can be performed in a common gallery when the earth is well rammed.——Should sand-bags be used in tamping, half-bushel bags are more handy and convenient than the ordinary bushel sand-bags. ——The mode of arranging the working parties in mining operations at Chatham is very judicious. The parties work in three reliefs, beginning at 6 A.M. and leaving off at midnight; each party working 6 hours. The officers exchanged duties in each relief 2 hours before the men, thus keeping up the chain of information.

230. The voltaic battery is now so well understood, and has been so successfully used in exploding charges of gunpowder, both under water and under ground, that there can be no doubt of its being the best method of discharging mines, as it gives the means of making the explosion at the exact moment required.*

* In that most excellent work (Jones's Sieges in Spain), Sir John Jones says, that at the siege of Burgos, the inexperienced miners there were 108 hours piercing through 60 feet: practised miners would have done it in 72 hours, which would give 20 feet in 24 hours; but at page 314, of the first volume of his Sieges, in detailing this operation, he says, the gallery was 3 feet wide by 4 feet high, "*the soil stiff, and standing well without support.*" Hence, expert miners

231. *Fougasses, or small mines,* in the defence of field-works, are strongly recommended. Mines are so called when placed at the bottom of small shafts from 9 to 12 feet deep. The powder is lodged in one of the sides of the shaft, and it is fired from a secure spot by means of a powder-hose or fuse brought up one side of the shaft.——*Of shell fougasses.* Shells may be buried singly, or in small heaps, and to be made to burst either under the ground, or on its surface.——If they are to burst under the earth, they must be sufficiently charged to produce a crater through which the pieces of the shell are projected.——If they are to burst on the surface, the requisite quantity of powder to produce a crater, and throw out the shells, must be lodged under them, while these latter need only have a sufficient charge to burst them.——In all cases a box is used, divided into two parts by a partition. The shells are placed in the upper part, their fuses project through the partition, and extend from $\frac{1}{2}$ to 1 inch below it.——In the lower part, the hose only is placed when the shells are intended to produce their own crater; but powder sufficient to produce the crater is introduced when they are intended to burst on the surface of the ground.

Description of Shell.	Full charge of the shell.		Depth at which the full charge produces a crater.	
	lbs.	oz.		
Calibre, $5\frac{1}{2}$	1	0	2	0
„ 8	2	9	2	10
„ 10	5	0	3	6
„ 13	11	0	4	7

cannot work at the rate of more than from 14 to 18 feet in 24 hours, where the soil requires cases to sustain it.——At the siege of St. Sebastian, in 1813, Sir John Jones details some of the mining opera-

Common and shell fougasses produce an effect only near to their craters; consequently, they should be exploded at the moment the enemy is above them.——*Fougasses* are one of the best means of stopping the impetuosity of an assailant; but they cannot be applied in every case. When the besieger is aware that the work is provided with fougasses, and this he should be suffered to know, his circumspection will increase. Soldiers who have once witnessed the springing of one of these small mines, are liable to be in continual apprehension of explosions; and a hidden danger produces upon them a much stronger effect than perils of a more serious nature, when openly encountered. The effects which mines produce upon the *morale* of assailants are, perhaps, the greatest advantage which they afford to the defenders. Should the fougass be either a box, containing three or four loaded howitzer or mortar shells, or else about twenty pounds of powder, a wooden trough communicates with this box, also buried in the ground, and protecting the powder-hose by which the fougass is fired. In order to place it a narrow trench is dug of the required depth; and after charging the mine, and laying the powder-hose or fuse in the trough, it is carefully fastened down, the trench filled up, and rammed.——The well, or chamber, after being charged, is filled up with stones instead of earth, to render the fougass more destructive. The hose-trough passes down the counterscarp under the bottom of the ditch, through the thickness of the parapet, into the interior of the work. It is sometimes made to stretch across the ditch, and is then

tions, thus: "The soil being a loose sand, the whole of the interior was obliged to be sustained by framework; the frames were placed *two feet* asunder. Three days were passed before the miners (uninstructed men procured from the regiments of the line,) could acquire any degree of expertness in driving the gallery; but after that period they penetrated and completed 16 feet in 24 hours with ease, even when the gallery had extended to a length of 80 feet.

supported by tressels; but this arrangement exposes it to continual accidents. If the box containing the charge be likely to remain long under ground, it is necessary to calk and tar it as well as the trough, to preserve their contents from damp. Great care must be taken to guard against precipitation, when about to spring a fougass, otherwise the chances are, that it will explode before the enemy reaches the sphere of its effects. Fougasses are very advantageous at the angles of dead ditches, where they may be placed about ten feet asunder; and also at about 10 or 15 paces from the ditch, at those points over which the enemy is most likely to advance.

CHAPTER IX.

DEFILADING. INUNDATIONS. DEFENCE OF VILLAGES. TOOLS REQUIRED FOR THE CONSTRUCTION OF FIELD-WORKS, &c.

232. *Defilading* is the proper arrangement of works, in order to parry the effects of commanding ground.——In field fortification, the limits for defilading are regulated by the range of musketry; that is, the horizontal limit is about 300 yards, and the vertical height above the top of the commanding hill is about 8 feet; for 8 feet is considered the height of the crest of a parapet, over which the assailants fire.

233. A work defiladed from musketry will also be defiladed from artillery, if the parapets, &c., be made sufficiently thick.——In an enclosed work, the interior place is limited by the projection of the crests. Open works are generally defiladed to a distance of 20 yards in rear of their gorges.——In no case should the interior slopes of the parapets be discoverable from without; whence arises the necessity of traverses to protect the defenders from enfilade, slant, or reverse fire: when intended for the latter purpose they are called *parados*.——A work may be so situated as to require defilade from a plain *a*, fig. 84, Plate X, or from the height *b* or *c* above it. The interior of the work D is exposed to *a*, *b*, and *c*, and arrangements must be made to protect it by traverses. A few cases will be explained to enable a student to understand the subject; the figures on defilading are diagrams merely illustrative, and not done by scale. In fig. 85, the nearest parapet *r*, to the elevated ground *f*, may be so heightened, that a line from a

man at *f* passing over it, clears the head of the man *e*, on the far parapet, by 3 feet; but if the command be great, as *g*, then a parados, or traverse *t*, becomes necessary: this may be made of earth; or, if against musketry, of two rows of planks, or stockade-work filled with earth; or as in fig. 42, Plate VIII: the dimensions of parapets *e* and *r*, and of the parados *t*, as well as its position, depends on circumstances which can only be fixed on the ground where the defilading process takes place.——Let fig. 87, Plate X, represent a lunette on a sloping plane of site, having commanding ground in front of its salient: the face *b g* and flank *g f*, with the usual height of parapet, may be defiladed by the traverses *a* and *e*, while the face *b*, *c*, and the flank *c d*, may have their parapets raised, as indicated in figs. 87 and 88: or a different arrangement may become necessary, as in fig. 89, where a traverse or parados is made on the capital rising to the rear, as indicated in fig. 89, and also in fig. 90, where *a' b'* represents the elevation of *a b* in fig. 89; in this case, the crests of the parapets are made parallel to the plane of site *k l*.

234. *To defilade from musketry.* See fig. 86, Plate X. Let C represent the angle of a lunette which has to be defiladed from the hill H, at 300 yards' distance; H being the summit of a pole 8 feet high, placed on the top of the hill: this would be the height of an ordinary parapet, should an enemy raise one on the surface of the hill, H. Upright poles are placed at all the angles of the lunette, and a line *m n*, is tightly stretched between the poles, marking the gorge of the work; then, at the distance in the rear at which it is wished to be covered, a straight edge or rod, *a b*, is fixed 8 feet above the ground; let the eye pass along this line, *a b*, and move *m n*, until the visual ray cuts the top of the pole H, and at the same time intersects the poles at the shoulder angles, and at flanked angle C, of the

lunette; the points at which the visual rays cut these poles will fix the heights of the parapets, and lines connecting these parts of the poles together will give the crests of the faces and flanks. A plane parallel to the visual ray, B H, would be the plane of site (8 feet below the defilading plane), and tangential to the brow of the hill from the gorge lines of the ground. Should this arrangement give a greater elevation to any part of the parapets than 12 feet, it is desirable either to lower the parapet at the gorge from 8 to 6 feet, or to excavate the whole or part of the interior of the lunette, and thereby obtain cover for the troops. The labour of forming parapets more than 12 feet high is so great that it should, if possible, be avoided. If the distance, *a b*, to the rear be considerable, where it is desirable to be covered from a fire from the hill, it would probably be a saving of labour and time to form a traverse straight across the gorge, or even on the rear of it, which would allow a considerable diminution of the height of the parapets of the lunettes.——This arrangement, it will be observed, places the defiladed parapet precisely in the same position, with reference to the hill, that ordinary parapets are in when situated on level ground; the plane of site being a tangent to the ground; the defilading plane 8 feet above and parallel to the plane of site. With the aid of a plane-table, the plane of site can be accurately and rapidly determined. Suppose the upper surface to be directed to the points of command, the intersections of that surface prolonged, with the poles planted at the angles, fix the heights of the plane of site.

235. If it were required to be defiladed from two or more heights, then the plane of site being at once tangent to two points of the surrounding ground, could not be made to pass through a given *line* at the gorge, as in the foregoing paragraph, but only through a *point* of that gorge: for exam-

ple, a point near the centre of it; which point must be raised 8 feet above the plane of site.——Let H and N, fig. 86, be two heights, E the salient angle of a lunette to be defiladed. In the centre of the gorge of the work, or at the point most distant from the heights, plant a pole F, standing 8 feet out of the ground. Before it place two others, *o* and *p*, and cause a straight edge or tightened cord to be moved up and down on them, until, when seen from the end of the 8-feet pole, it appears to touch at the same time both the points, H and N (the latter being poles each 8 feet high on the summit of the hills): this will be the defilading plane, and the parapets must be raised to meet, and even to exceed it by a foot or two.——It often happens that a single plane of defilade would give too great a relief; the left part of the work must then be defiladed from the height, H, and the right part from the height, N: and as this would expose the faces to be seen in reverse, it becomes necessary to construct a traverse of a height and thickness sufficient to screen the troops when on the banquettes from slant or reverse fire: the traverse is usually made on, or nearly on, the capital; it should not be less than 6 feet thick at top; and, unless reveted, its slopes should be at 45°.——A triangle, constructed of smooth laths (the ends halved into each other, so that the upper and under surfaces may be parallel), and each side of about a yard in length, is convenient to use to find the plane of site.——If a line at the gorge be given, as *m n*, fig. 86, place one side of the triangle on this line, and move the apex until the surface of the triangle is a tangent to the pole on the commanding ground.—— At the pole near the gorge of F, fig. 86, place one of the angles of the triangle, and let the triangle revolve about that point until its surface is a tangent to the poles, or H and N on the hills.

236. The most simple mode of determining a traverse

is to assume the most convenient position for it, and then to give it a sufficient elevation to cover the men placed on the banquettes on each side of it. At the same time, the planes of defilade of the parapets should pass 8 feet (or $6\frac{1}{2}$ feet at least) above the ground towards the centre of the traverse.——The above mode of defilading is only applicable to works that rest their extremities on a river, the opposite side of which is possessed by the defenders; or to ground where an enemy cannot turn the work or get to the rear of it: for if such a work were situated in a plain, and an enemy able to approach from the rear (even if the rear be closed by a common parapet or stockade), yet as the parapet is probably 10 feet high at the salient and 7 at the extremity of the flank, the crest between the 10 and 7 feet points being a connected oblique line, a considerable portion of the inside of the parapets would be seen from the plain in the rear, and the defenders on their banquettes would be exposed to an enfilading and reverse fire.

237. Therefore, in order to defilade enclosed works such as redoubts, it is necessary to protect their interior, not only from the heights around, but also from the fire of an enemy approaching from the plains. See figs. 91 and 92: the former shows a bridge covered by a redan with flanks on one side of the river, and two square redoubts on the opposite side; all commanded by a range of neighbouring hills within the range of artillery and musketry. It is supposed that an enemy might find the means of crossing from the left to the right of the river, 70 yards wide, and attack from the plain as well as from the hills; the bridge has therefore, on the right bank, a little redan with a traverse, *t*, to protect it from the fire of the hills.——To defilade the works, the following arrangement might be made: a small increase of height at the salient of the great

redan, A, with interior traverses of the required height within the work, as shown by lines in the redan ; one on the capital, spreading out into two, just before the bridge : as well as smaller traverses, *d d*, all intended to protect from the hills on the left bank, as well as from the plain on the right bank of the river.

238. The redoubts on the right bank of the river must be defiladed from the ground on both sides of the river. The redoubt, *c e*, fig. 91, is shown in section in fig. 92 : this section is taken on the diagonal, *c e*, of fig. 91 : the shaded parts of fig. 92 represent the elevations of the faces of the redoubt. The two faces of the redoubt forming the angle *e*, fig. 91, have their parapets of the usual height of 7½ feet, as seen in the section at *a*, fig. 92 : they are shielded from the fire of the hills by the traverse that divides the redoubt into two parts perpendicular to the diagonal, *c e*, fig. 91 ; which traverse is seen in section, fig. 92, and is about 12 feet high : the salient of the redoubt next to the hill *c*, fig. 91, has an elevated or cavalier parapet, called a *bonnette*, 12 feet high, to prevent the faces forming the angle, *c*, from being enfiladed from the hills : this bonnette is seen in section and elevation in fig. 92. The two faces forming the angle *c*, in fig. 91, have sloping planes of site and defilade, as seen more clearly in fig. 92, so that the line of fire, *f f*, from the hills passing over the bonnette, may clear the heads of the defenders on these faces. If *a b c*, fig. 92, be the original level of the ground, it often becomes desirable and necessary to excavate below the ground line (as shown near *b*), in order that the plane of site, or the interior of the redoubt, may run parallel to the crest, and thereby give proper cover to the defenders. The shaded part sloping upwards from *b*, underneath the traverse, indicates a passage (made with mining cases) in order to communicate between the two

sides of the traverse: this passage may be covered by a little traverse in front. The other redoubt on the right of the bridge would be defiladed by some similar process suited to its position. It will be observed that the faces of these two redoubts are so disposed as to flank the works on the left bank: and that the prolongations of these faces would fall clear of the hills. In tracing field-works near hills, the faces should, if possible, be so directed as to fall clear of the hills, that they may not unnecessarily be exposed to enfilade fire.

239. If a piece of ground be entirely surrounded by hills, it is impossible to defilade it completely: positions of the kind can only be defended under very peculiar circumstances. It may happen that a village or town commanded by a neighbouring height, or even several heights, may have such a mass of interior buildings of a solid character, that they may serve the purposes of traverses and parados; and such a position may, with a little engineering skill, be made defensible: or, there may be a natural rise of ground within the circuit of a village, which may make it a good position, and capable of defence, although commanded by heights: but in general, commanded ground should be avoided for defensible positions.

240. *Inundations.* Whenever local circumstances permit the ditches to be filled with water to the depth of five or six feet, this means of defence should not be neglected; as not only the defects of dead angles will be greatly remedied, but the enemy will be forced to employ more than ordinary means to approach the work. If a small river or rivulet passes within musket range of the work, the difficulty of access to the latter may be increased by throwing up some dikes across the course of the river, thereby spreading an inundation over the adjacent ground. These dikes are so placed as to be enfiladed or flanked by the fire of the

work ; and when time and workmen are not wanting, the most exposed amongst them may be covered or supported by a small redan, to prevent the enemy from arriving at them, and draining off the waters of the inundation. Experience has proved that a good dike should not be higher than 9 or 10 feet: hence, from one dike to another, when several are used, the difference of level between them should be only $4\frac{1}{2}$ or 5 feet, in order that the most shallow parts between two dikes shall not be fordable. Therefore, after fixing the place for the first dike, that of the others will depend upon the natural slope of the waters, which must be determined by levelling, or ascertained by information obtained from the neighbouring millers. The level of the second dike will be placed $4\frac{1}{2}$ or 5 feet lower than the first ; the third as much lower than the second ; and so on with the rest. Hence it follows that this kind of defence is inapplicable to a mountainous country, because the slopes are too great: it is equally so to a country where the bed of the river is not sufficiently confined, and has its borders too far apart ; because the dikes, in this case, would require too considerable a length, which would entail extraordinary labour in the construction and difficulty in the defence.——It is impossible to fix a limit for the length of the dike, because its construction depends upon the means at disposal. In some cases, a dike one hundred yards long would be a prodigious undertaking: in other circumstances, the construction of such a dike would be sufficiently practicable. But as neither the profile of a dike, nor the length of its fall for the evacuation or running off of the superfluous water, are dependent upon its length, some details upon the subject may be given. When a dike is not liable to be battered by artillery, a thickness at top of $4\frac{1}{2}$ feet will suffice, supposing the dike to be made, as it most generally is, of earth. The earth may be taken from the lower or ebb side: if it be not

sufficiently binding, and let the water filter through it, proper earth must be brought from the neighbouring country wherever it may be found. This will augment the trouble, but it is indispensable for the goodness of the work. The best way to prevent filtration is to line the inside of the dike with clay. When the dike is exposed to cannon, its summit ought to be proof, that is about 10 feet thick. Its natural slope may be given to the earth on both sides of the dike; but for greater perfection, the upper slope, that is, the one on the flood side, should be made the gentlest, by giving its base twice the length of the dike's height; to avoid the shock of the stream, and to diminish its pressure. ——If, after constructing the dike with earth, according to the profile above indicated, the waters were allowed to rise above it and flow over the whole of its length, it would not be long before the whole dike must be destroyed, supposing the current were at all rapid. To avoid this inconvenience, a space is left 8 or 10 inches lower than the rest of the dike, and of sufficient breadth to allow a free passage to all the water of the stream. This part, forming a cavity on the top of the dike, and constructed more solidly than the rest, is called *the fall*, or *deservoir*. This fall is constructed with fascines, that is, after building the dike to a certain height, a double revetment of well-picketed fascines is commenced; this revetment must not only cover the top of the fall and the ebb side, but must extend underneath, forming a bed to break the fall of the water, and prevent its undermining the foot of the dike. With respect to length, this bed is made to extend a little beyond each extremity of the fall, in order that it may more completely fulfil its object. To give greater solidity to the bed of fascines, the tops of the pickets, which are driven through the mass, may purposely be left a little above ground, and have hurdle-work interwoven round them. The pickets or stakes ought to be 4½

feet long. The same hurdling might be made on the revetment of the fall; but if this should appear too laborious, the extremities of the fascines should at all events be secured by others placed crosswise, and strongly picketed into the first. The cheeks of the fall are likewise reveted with fascines, which are placed at right angles with those of the top of the fall and picketed to them.——Inundations of the description and extent just mentioned, are rarely within the compass of field operations: to block up the arches of a bridge, so as to cause the water to rise upon the upper side of it and overflow its banks, is a ready and effective way of increasing the obstacles to an enemy's approach.

241. Let fig. 96, Plate X, represent a fortified village, having a small river covering one side of it, with a bridge across, as seen in this figure at b' b''; the stream running in the direction of the arrow: by examining the figure it will be seen that the banks above the river, from m, n, up the stream, are low, while they are steep, rocky, and high from m, n, down the river. If the arches of the bridge be blocked up so as to allow only a small quantity of water to pass through, the low bank above m, n, would overflow, and cover the low ground with water, and thus serve to protect in a great measnre the side of the village from m to p.—— When any part of the ground round a work is low and marshy, but destitute of such currents of running water as would prevent an inundation to be formed, holes or trenches 5 or 6 feet deep, and as many wide, may be substituted. The holes and trenches will effectually stop the enemy, and he will be obliged to fill them up before he can arrive at the counterscarp which they cover. The above mentioned breadth will be sufficient to render them impassable for men loaded with arms, ammunition, and knapsacks. The earth excavated must be carefully and evenly strewed about, both

to prevent it forming small islands, which would assist the assailants, and because any rise of ground in the vicinity of a field-work may be detrimental, owing to the small relief usually given to the latter. If the localities be such as offer to the enemy the facility of draining the inundation, or sheet of water, the holes and trenches above mentioned may be multiplied, as they will contain water, and be a serious obstacle even after the draining is effected.

242. *Defence of villages.* In defensive warfare, it is often necessary to intrench towns and villages, either for the purpose of securing them from the incursions of small parties, or to serve as points of support for the movements of troops. If a town or village be commanded on all sides, or even by great elevations on one side, if the houses be of wood and the roofs thatched, so as to be easily set on fire, such a position should be avoided as a place of defence to be intrenched. Neither should a detachment of troops occupy a town or village, the extent of which is beyond their means of defence; unless a part of the village can be easily cut off from the rest.

243. The first thing to be done is to clear the approaches to the town, by levelling houses, hedges, shrubberies, and whatever may not be of advantage to the defence, or whatever may favour the assailants. Trees and shrubs ought to be cut two feet from the ground, that it may serve to impede the advance of the enemy without masking the fire of the defenders. The hedges and walls that run towards the defence, and that can be raked or enfiladed on both sides, should be left standing, as they will separate the enemy's columns in their advance: but those walls and hedges that run parallel to the outline of the works should be levelled, as they would afford cover to the enemy. All wet ditches in the surrounding fields should be deepened and widened, if time admits of doing so: dry ditches should be filled up,

that they may not give cover to an enemy. The next object is to form or complete the enclosure round the town. For this purpose, advantage is taken of buildings, walls, and fences, applicable to the defence. The openings which remain must be closed by means of palisades, stockades, parapets, and ditches, strengthened by abattis. All streets leading directly out of the town must be barricaded: these barricades ought to be sufficiently thick to resist field artillery, and high enough not to be easily got over: they ought to be flanked by loopholing the neighbouring houses. Fig. 90, Plate X, is the plan of a fortified village, with references attached to it. The barricades may be constructed with palisades, or in stockade work; or else a frame may first be made with uprights and planks, and then it may be filled in with earth or dung. When pressed for time, such barricades may be formed by filling carts or waggons with earth or dung: the wheels are taken off, and if trees be at hand, an abattis may be formed in their front. Barricades may be made as specified in paragraph 182, and seen as in fig. 37, Plate VIII. The slight fences and palisades, either of wood or iron, that are found in every village, may be turned into barricades by additional spurs and braces, and by building a wall of sand-bags behind them; always taking care that the loopholes for the musketry are at least 8 feet from the ground without: planks would probably be required inside, raised high enough to form a banquette. The doors and windows of buildings that are occupied for defence should be blocked up with sand-bags, supported by frames of wood; but such as must be left open for communication, should, if possible, be covered with sheet iron $\frac{1}{4}$ of an inch thick. Should a building have to be defended that has no projecting wings or porches, it will be necessary to make an arrangement in order to obtain a flanking defence, as in paragraph 182.——If there be any drains or galleries

under the town, they must be stopped by gratings or otherwise.——Advantage must be taken of the most salient points to establish flanking defences, whether by loopholing the houses, constructing tambours,* or any other field-works. ——If there be artillery, it ought to be disposed so that it will fire upon the enemy in his advance, and protect those parts of the defences which are most liable to assault. It will generally be placed behind salient points of the line of defence, whether consisting of earthen works, tambours, or of old walls. In the latter, embrasures must of course be opened.†——It is proper to cut a ditch in front of the parts where the defence consists of buildings or enclosures; and, if there be time or means, it is desirable to continue this all round, and to increase the obstacles by palisades and abattis. ——If a town be situated near a river or stream, by which any part of it can be covered by inundations, it should never be neglected.——If there should be any old castle, jail, or large substantial building inside of the town, it may be converted into a keep, by blocking up useless openings; by covering entrances or any unflanked portion of the wall with a tambour; by loopholing the walls, and by surrounding them, if possible, by a ditch with palisades and abattis. The solid building, K, in fig. 96, is of this character. Villages being generally surrounded by gardens enclosed by live hedges, these hedges may be made use of in forming the line of defence. A small ditch may be dug in front of them, or else an abattis must be placed there as an obstacle. ——That the communications in the interior may be free,

* A tambour is merely a stockade, traced like a redan with a salient angle, and having sometimes a kind of shed or roof on it.

† Flat-roofed buildings are sometimes found strong enough to bear light artillery, whence a commanding view of the country may be had; ruined houses with strong walls have been filled up with earth and rubbish, so as to form a solid cavalier battery.

all hedges and enclosures, which may in any way impede the movements of the defenders, must be levelled: thus, *t*, *t*, *t*, *t*, fig. 96, represents a free communication inside of the works, to enable the defenders to carry support rapidly to any point pressed by an enemy.——If there should only be troops sufficient to defend part of the village, then a part only must be intrenched, which must be separated from the rest of it by cuts and barricades.—— In tracing the outworks of the village, advantage should be taken of the walls, hedges, and ditches, where they can be useful to the defence.——The hedges and walls preserved may serve as curtains to the principal intrenchments: sometimes they form the only defence, and then care should be taken to preserve those which flank each other. In examining fig. 96, it will be observed that the tracing gives a succession of bastions, or of salient and re-entering angles; some of the original garden-walls and good hedges form the curtains: the parapets of the bastions are of the common kind, or made of good casks, as *c*, forming a strong interior revetment; or of stockades, or barriers, &c., as seen in figs. 40 to 44, Plate VIII. The main streets are also barricaded, as *b*, *b*, and the keep, K, commands a considerable portion of the interior, as well as the bridge and the opposite side of the river: the bridge is covered with a double line of works, and flanked by artillery, *m*, *i*, and K, *i*. Good abattis, *x'*, *x*, *x*, cover the salients and parts most in advance. The enclosure is made complete all round the village. The development of the whole of these works is about 1300 yards, and could be defended by one battalion of 800 or 1000 men, as every part will not require to be fully manned at the same moment.

244. The following means are to be employed to render hedges and walls serviceable to the defence:— If the hedge be more than 6½ feet high, cut off the

branches to that height, and work in the parts so cut, to strengthen the remainder of the hedge: excavate a ditch in front, without being particular as to its dimensions or regularity of form, and let the earth be thrown over the hedge, or brought in by a gap within it, and laid against it, so as to form a kind of parapet of from 15 to 18 inches thick at the top; and with a portion of the earth a banquette may be made, to enable the defenders to fire over this parapet.——Sometimes there may not be time to make the arrangement above described; then dig a trench in the rear of the hedge, and form the parapet with the excavated earth.——If the hedge be planted on a steep slope, the earth should, as in the preceding case, be taken from the rear.——Should the hedge not be 6½ feet high, a small ditch should be made in front, the earth be thrown over the hedge, and a trench be dug in the rear to obtain cover behind the parapet. The earth of this trench, the depth of which must depend on the height of the parapet, may be used to give a greater thickness to the parapet and to make a banquette: or a trench may be dug in the rear of the hedge, 2 feet deep, and 3 feet wide at the top, and the earth be thrown against the hedge to form a parapet 2 feet high, behind which cover may be obtained by stooping. This trench might easily be excavated in half an hour, and would be of great assistance to light infantry. The hedge thus prepared should not be clipped, in order that the men behind it may be concealed from the view of the enemy, and that it may oppose a greater resistance to the assailants when endeavouring to force it.——A strong hedge thus prepared is an excellent means of defence. A thin hedge is but a very slight obstacle, and should therefore be avoided. Neither should those hedges be occupied which can easily be enfiladed by the enemy's artillery.——A wall 4 feet high may, without any prepa-

ration, serve as a parapet; but if it be 6 feet or more, loopholes should be pierced.——Loopholes generally are of an irregular form, pierced roughly in the walls with crowbars, chisels, hammers, &c.; and it rarely happens that there is time to make them in any other manner. They should then be made as small as possible.——To prevent an enemy closing on the loopholes, a small ditch should be dug on the outside, 3 or 4 feet deep, and the earth be laid against the wall. The depth of this ditch being small, its slopes may be steep. If the wall be more than $4\frac{1}{2}$ feet high, but too low to admit of loopholes being formed in it, a banquette should be made to enable the defenders to fire over the wall. Instead of making a banquette, the top of the wall may be cut down at intervals to form small embrasures 3 feet apart. ——With such walls as in figs. 40 and 41, Plate VIII, two lines of fire may be obtained. All defensible houses should be arranged as specified in paragraph 182.

245. In the defence of a village, the rule is to allow 1 file of men for every running yard of parapet, as a general guide for the parts exposed to an enemy's attack. Such portions of parapet as may be covered by an inundation, or that may have obstacles that make it difficult for an enemy to advance to the attack in column or in good order, may be calculated to require 1 man to every yard, to every two yards, or to every three yards, according to circumstances; reserves being made at the time of attack, of the greatest number of the defenders that can be withdrawn from the unassailed sides. Respecting the defence of single buildings, whether they are detached, or whether they form part of the general outline of the defensive works, it will be sufficient to average 1 man for every 4 feet for the lower stories; 1 man for every 6 feet of the second story; and for higher stories, 1 man for every 8 feet.*

* The solid buildings in almost every village in India, such as

246. *Interior keeps, redoubts.* The surest way to support the courage of the defenders, and consequently to

Pagodas, Mosques, Choultries, or Caravansaries, with their enclosing walls, afford most excellent means of forming very strong redoubts or keeps; and the formidable quickset and aloe hedges which abound in the villages of Asia are natural defences, and require but little art to render them inattackable to troops without artillery.

Extract from Captain Brown's able defence of the little fort of Kahun, in Beloochistan, in 1840.

(27th May.)—"Busy in clearing the ground of every thing in the shape of trees or shrubs for 200 yards round the fort outside."

(29, 30, and 31.)—"Commenced digging deep trenches along the foot of the walls inside, planting sharp pointed stakes in them: pulled down all houses touching the walls, to prevent the enemy's landing, should they succeed in mounting the walls in overwhelming numbers. This gave them a drop leap of 25 feet on to a body of stakes."

It was an excellent measure thus to prevent any communication from the ramparts by houses, walls, &c., as well as render it difficult, if not impracticable, for an enemy to descend from the ramparts, even after succeeding so far as to get on them. Strong barriers across ramparts (having good gates), at intervals, are also useful: all to be raked from the interior defences.

Defences of the character thus resorted to, with a view to obstruct the assailants' progress, *after the outer works are carried*, require to be strongly flanked or commanded by the defenders from other points; and when thus completely scoured or fired down upon, such portions of the defences may obviously be left without other protection. For supposing works thus as it were cut off from a ready retreat or support, to have defenders upon them at the moment of assault (except where there may be communications with other parts of the works), such defenders would, if overpowered, be completely sacrificed; and the very knowledge of this alternative would paralyse the energy of all but men driven to desperation. As a general rule, therefore, obstacles of the nature resorted to at Kahun, apply to peculiar positions; where, as in the case of that brave and honourable defence, the garrison is very small and incapable of manning the entire line of enceinte: when it is desirable to limit the points of defence to a few strong positions; cutting off, as it were, intermediate lines by obstructions like those so judiciously resorted to by Captain Brown, and concentrating upon such lines strong commanding fires, both direct and flanking. In such cases, obstacles, viz., ditches or trap-holes, with abattis or stockades, should be resorted to as much

increase the strength of a work, is to facilitate their means of retreat, in case they should be overcome; and thus to procure for them a place of refuge, in which they may capitulate upon terms the more honourable in proportion as they have defended with gallantry the principal work. This may be accomplished by the construction of an interior redoubt, when the magnitude of the principal work will permit it. In forming such redoubts, care should be taken to dispose them in such manner that there shall not be a single point within the principal work undiscoverable by their fire; and their size must be adapted to the numbers for which they may be required to afford cover. If the principal work be one of a considerable extent, the redoubt may be made with earth, like an ordinary redoubt; but then a command must be given to it over the parapet of the exterior work, in order that the enemy, when standing

as possible exteriorly to the walls to be defended, as well as interiorly in the manner applied at Kahun.

As connected with such defences, it may not be irrelevant to observe, that were a line of mountain ridges required to be defended, it is possible a natural scarp on the interior side might occasionally favour the defence, even where the exterior might be easy of ascent. If the interior natural scarp is of a height precluding a safe descent, viz., beyond 35 feet (a height considered *beyond escalade*, from ordinary ladders breaking if loaded to that height), in this case, such portions of ridge should be cut off and effectually separated from the rest by ditches, &c., with the above-named additional obstacles to assault, and supported by flanking fire from each extremity.

A combination of exterior with such like interior defences, would prove the most expeditious, as well as the most effective, mode of defending such lines of heights. For supposing the assailants to attempt to force a part of the position thus cut off and flanked, they would find descent impracticable by wooden ladders, and they would be mown down by a destructive fire, raking the whole approach, as well as crossing and completely scouring the interior of the precipice.

This idea is thrown out with a view to economising the number of defenders of any lengthened line of works, and the principle may be applied to permanent as well as to temporary positions.

upon the parapet of the latter, may be unable to see into the redoubt. In the fortified village, fig. 96, Plate X, K is supposed to be a large, substantial, masonry building, surrounded by a good wall, *w*, *w* : this is made the keep of the village, and has a ditch separating it from the rest of the work. In the large redoubts in the Duke of Wellington's celebrated lines of Torres Vedras, the interior space was generally divided into several parts by parapets, so that if the outer parapet was carried, the interior ones could prolong the defence ; as seen at *d*, D, *d'*, fig. 82.

247. *Blockhouses* are a species of retrenchment peculiarly adapted to woody countries : because the materials for their construction are found upon the spot : and as these countries are mostly mountainous, the enemy cannot without much difficulty transport his cannon with him. There is, besides, in such countries difficulty in finding a site whereon to construct a work of the ordinary uncovered kind, which may not be seen into and commanded by some neighbouring height. The plan of a blockhouse is usually that of a rectangle, eighteen or twenty-four feet wide in the inside ; but when it is possible to give it greater dimensions, its plan is that of a cross, so that its fires flank one another mutually. The profile of the blockhouse will vary according as it may be liable to an attack of infantry merely, or of infantry with artillery. In the former case, its sides may consist simply of rows of contiguous trunks with loopholes made in them three feet asunder. In order that the enemy may not be able to set fire to the work, he must be kept off from it by a ditch, the earth of which is piled up against the work as high as the loopholes, and is moreover employed to cover the roof, and form also a small glacis round the work. The only difference between a redoubt intended to resist artillery, and that which has been just described, is that, instead of a single row of contiguous trunks of trees

or piles, the former is constructed of a double row; the interval between them being filled with well-rammed earth as high up as the loopholes, the whole composing a wall three feet thick. This work being of a more important nature than the preceding one, its inside dimensions should be twenty-four feet, and the tie-beams, owing to their length, must be composed of two pieces scarfed in the middle, and moreover supported by strong stanchions resting on a ground-sill. These may become temporary barracks; the cots will serve as banquettes for firing through the loopholes.*

248. *Tools and stores*† more or less necessary, where

* But this description of the mode of erecting blockhouses being confined to the usual practice of European service, would be incomplete without some reference to the peculiar construction and employment of similar defences in the forest warfare of North America. By the universal expertness of the backwoodsmen of that country in the use of the axe, works of the kind are constructed with astonishing rapidity, and rendered capable of opposing a formidable resistance. The Americans build their blockhouses, like ordinary log-habitations in their new settlements, of thick horizontal trunks of trees, roughly squared; and several of these works, disposed like bastions at the angles of an area, in such order as to flank each other, and connected by a stockade, or curtain of close palisading of upright trunks of trees, loopholed for musketry: this is a temporary field fort of no despicable strength. Even when artillery can be brought against these works, their defenders, protected by interior traverses of earth, suffer little loss, while the blockhouses and stockades, being formed of green timber, do not easily admit of being breached; and may equally—as was proved in one instance, during the war of 1814, on the Canadian frontier—defy any attempt to set them on fire with red-hot shot. Against mere musketry, or an open assault, it is evident, that, if well defended, the nature of such enclosed and flanked buildings can leave a garrison little to fear. The American blockhouses have sometimes an upper story, projecting sufficiently over the lower one, to afford a plunging fire through the loopholed floor, like a machiacoulis. See Appendix (*B.*) for some historical details of the defence of posts.

† From the Aide-Memoire.

temporary works are to be thrown up, and they should be furnished in the required proportions to any detachment whose duty it may be to strengthen, and afterwards defend a post.——They are classed in three divisions, that their separate uses may be apparent.

Class 1.—*Field-service tools.*

Shovels, pickaxes, felling-axes, bill-hooks—for sinking trenches, forming breastworks, felling timber, making abattis and obstructions, &c.

Class 2.—*For houses, walls, &c.*

Sledge-hammers, hand-borers, crowbars, saws, augers, spike-nails—for forming loopholes, breaking through walls, preparing timber for barricades, stockade-work, &c.

Class 3.—*General service and purposes of defence.*

Sand-bags, rockets, small shells, hand-grenades.—The sand-bags for blocking up windows, and forming loopholes, &c. The rockets and shells for defence of houses and intrenchments.

The proportions of these necessary to be demanded, will of course vary with the description of work which may be anticipated.——For example, in throwing up earthen works in an open country, a pickaxe and shovel for every man that could be employed on the breastworks would be wanted. If an ABATTIS could be formed, and there were fences to be cut down and levelled, one-third of the men would be advantageously employed with felling-axes and bill-hooks. In a case where houses were to be placed in a state of defence, walls would have to be broken through for making loopholes: and windows, doors, and passages to be barricaded: here crowbars, hand-borers, sledge-hammers, spike-nails, and saws, would be required in greater proportion than spades and pickaxes.——Rockets,* small shells, and

* As an illustration of the use of rockets, it may be mentioned,

grenades, are mentioned as being very powerful and attainable auxiliaries in the defence of posts and houses ; and one great advantage of them is, that anybody who has common sense may use them, or at least be instructed in the requisite precautions in a few minutes.—— A certain *division of labour* must also be attended to, and a man should always have a tool put into his hand, that he has been accustomed to use : carpenters should therefore be employed where saws and axes are wanted ; miners and blacksmiths where walls are to be broken through ; labourers where the spade and pickaxe come into play. Those who never handled tools of these descriptions would be most useful in collecting materials. It would be well also to select such men for the first tour of duty, as patrols and sentries, and to employ the best workmen in overcoming the greatest difficulties, which are usually found in the commencement. A little foresight will not be misapplied, in considering these points. ——It is useful to obtain the assistance of the inhabitants, in executing works of this description, and an officer should always have authority to enforce their attendance, and to pay them in proportion to their exertions. They should also be required to bring with them whatever tools they can best use, or that are most wanted.

that on one occasion, during the late war in Canada, an American gun-boat took up a position which enfiladed a situation where a bridge that had been destroyed, was being re-established ; from whence she kept up a fire that bid fair to stop proceedings. Artillery could not be brought up, but luckily, rockets were thought of, and a few were obtained from the rear. The second that was fired entered her bows, and caused so many casualties, that the 24-pounder was reduced to silence, and it was only by a shift of wind that the boat was got off, after being driven close in shore, and many of the remaining men being killed or wounded by a light company that ran into the water up to their pouches, in the hope of taking her.

ON THE

ATTACK OF A FORTRESS.

PART III.

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CHAPTER X.

ON THE ATTACK OF A FORTRESS.

249. It is now proposed to give a popular view of the process of a regular attack: the reader must refer to the Author's larger work, entitled, "A Treatise on Fortification and Artillery," in order to enter upon the details connected with this subject. It is sufficient to observe here, that in order to undertake the arduous operations of a siege, the army, or divisions of the army, appointed for carrying on the siege, must be free from interruption during its progress, and have all the *materiél* for the engineers and artillery departments either on the ground, or brought up to the place with such security and regularity, that there may be no want of proper supplies from the commencement of the siege in breaking ground before the fortress until it falls.

250. The success of a siege depends chiefly upon the combined skill and power of the engineer and artillery departments: these must be fully supplied with ample means, good sappers and miners, with abundant stores: a powerful, well-manned, effective train of heavy iron ordnance, with well-selected ammunition for overwhelming the defences, with an increasing fire of solid shot, shell, spherical case, canister, &c.

251. The reader is referred to Plate VII, which represents three fronts of Vauban's first system; and the process of attack against them: this process may be divided into three distinct periods, and they are distinguished on the plan by the *first*, *second*, and *third parallels*. A glance at the plan will show that the first parallel is of great extent, upwards of 3000 yards of parapet and trench, and that it embraces the prolongations of the faces of all the defensive works, the fire from which commands the ground to be worked over; in order to reduce and capture bastions A and B, and ravelin C. This first parallel has a profile like figs. 1 or 2, Plate VIII: it is constructed on the first night of breaking ground by a very strong working party; and if the men be placed at 6 feet apart, the strength of the working party will be 1500; besides the zigzag trenches of approach opened from the first parallel to the rear, leading to the engineer and artillery depôts, which will, perhaps, require 500 additional workmen. The outline of this parallel and the trenches to the rear, are traced by white tapes by engineer officers at night-fall; after which, the working parties, (each man with a light pickaxe and shovel,) are led to their places, and made to lie down, covered in front by an armed party having advanced pickets and sentinels to repel any attempted sorties (all lying down). When all is prepared, at the appointed signal the whole working party commence, and they should clearly know, that a new party will not be sent to relieve them until the required quantity of work is completed. The moment the trench is sufficiently deep, and the parapet affords shelter, the covering party retire into it, and become the guard of the trenches. This parallel becomes the base from which the operations are carried on. The plan shows the positions of the batteries upon the prolongations of the faces of all the works attacked, and of the neighbouring works

bearing on the ground over which the assailants must pass; the advance cannot be effected until the artillery of the defenders be so subdued as to render sapping practicable.

252. One of the leading elements of success arises from the advantages which the assailant possesses on this enveloping and extensive parallel, of placing his heavy guns in the positions best suited for their destructive work, while the defensive artillery must, from the comparatively contracted position of the defences, be more limited in their action. Before proceeding to enlarge on these batteries, it is necessary to make a few remarks on this parallel.

253. The distance of 600 yards is selected as suitable for the first parallel, as here there is little to fear from musketry, grape, or canister; but when the localities of the ground require that any portion of the parallel should be advanced or retired, in order to command the ground in front, it should be done. The distance of 600 yards also is too great for sorties from the place to hope for success, and to retire without great loss. The development of this parallel is usually so great, that the defenders would not think of expending ammunition upon it, unless it be to concentrate a fire upon any suspected site of a battery, &c. Moreover, batteries in this parallel are at a very good distance for ricochet practice. Good epaulements should also be prepared behind the extremities of the first parallel, for the protection of cavalry, who may be required to act against sorties. See Plate VII. The ground around is supposed to be a plain, the first parallel extends so as to embrace the prolongation of the left face of ravelin F, and the right face of ravelin E, the guns of which command the ground to be worked over; where batteries No. I and IX are constructed. But should the localities prevent the parallel being thus extended, and oblige the assailant to terminate at H and I, the (dotted) battery, 41,

would be made, in order to contend by a direct fire against the right face of ravelin E; and the battery 40, against the left of ravelin F. These batteries, 40 and 41, would have to be armed with a greater quantity of artillery than Nos. I and IX, nor would they, even then, be so efficient as the latter: for ricochet fire is superior to direct for subduing an enemy's defences. It is, therefore, best, if possible, to extend the parallel, in order to obtain a good position for the batteries for ricochet practice. Should any rising ground (as seen on the right of the first parallel, Plate VII,) be on the prolongation of any of the works, it would be preferable to the level ground for the construction of the battery (as dotted on the rising ground at *y*): such a site offering itself either in front or in rear of the parallel, or even a little out of the prolongation of an enemy's work (provided it is on the inner side of the prolonged crest), should be taken advantage of.——Should the site of such a hill or rise be too rocky or hard for excavation, the construction of a sand-bag battery may perhaps be practicable, as described in paragraph 197, Chapter VII.——Should the fire of the faces of any of the works, the prolongations of which fall beyond the sphere of the first parallel, become troublesome, batteries for subduing these defensive works, by a direct fire, must be established: for instance, if the fire from the right face of bastion D, disturbed the offensive proceedings, battery *z*, would be erected to act against it by a direct fire of heavy iron guns, and a vertical fire from mortars.

254. On the morning after breaking ground, the engineers determine the positions in the parallel for the construction of the batteries to be raised to subdue the fire of the place: the situations for the ricochet and enfilade batteries are fixed at the spots where the prolongations of the faces of the various works (that command the ground to be

passed over) fall into the first parallel; and those for direct fire are opposite to the faces to be counterbattered. See Plate VII. It is of the utmost consequence to complete the batteries on the first parallel as soon as possible, that the fire of the defences may be checked and subdued by the combined efforts of the enfilade, ricochet, direct, and vertical fires, of the besiegers' batteries. It is impossible to push on the trenches of attack until the artillery fire of the place is subdued by the superior fire of the assailants' batteries on the first parallel: hence every effort is made to effect this object. The first parallel then becomes the base on which all the batteries are constructed, as No. I, II, III, IV, V, VI, VII, VIII, IX, Plate VII. The reader is referred to Chapter VII, where the construction of the offensive works in a siege is fully entered into. In Plate VII, the left of the first parallel passes over a slight rising ground: the soil of which is supposed to be a sandy gravel, and suited for sunken batteries. Hence battery IV, to enfilade the left face of ravelin C; battery III, to enfilade the right face of ravelin F; and battery II, to enfilade the left face of bastion A, being all on this rising ground, are all sunken batteries. The remainder of the batteries on this parallel (except No. VII) are elevated batteries.——Some of these batteries may subsequently have to be removed and placed further in advance; but it is most desirable that they should act efficiently against the defences from the first parallel, because at this distance they are, 1st, out of the range of the musketry of the defensive works, and the gunners are therefore liable to fewer casualties: 2nd, sorties are not likely to be successful against these distant batteries: 3rd, the guns and ammunition are more easily brought up.——While the arming and practice of the batteries is going on, the engineers prepare for pushing the trenches towards the place. These are constructed in a zigzag direction; so that, when

the gabions should be filled and musket-shot proof in fifteen minutes, after which the earth excavated is thrown beyond the gabions to form the parapet; ample cover should be obtained by daylight next morning, as well as a respectable width of trench finished, as each has only the breadth of two gabions (about 4 feet) to excavate. (This process is called the flying-sap.)——The second parallel will probably be excavated on the fifth or sixth night.——The parapets of the second parallel, as well as those of all the other parallels nearer to the place, must have sufficient thickness to resist the fire of the artillery of the place: the first parallel from its great development is a mere screen and covered post, and an enemy would not waste his ammunition by attempting to destroy it: but were he to concentrate his fire upon some particular suspected spot of the second parallel, which is often much less than the first in its extent, and within 300 yards of his guns, the communication might be seriously interrupted; consequently its parapet must be reveted interiorly and solidly, as seen in fig. 3, Plate VIII. On the night of constructing the second parallel, some zigzags of approach beyond it may be traced and executed by the flying-sap: but, from the proximity of the place, few opportunities will afterwards present themselves for this expeditious mode of construction, unless the fire be very slack indeed.* The

* At page 208, vol. ii., Sir John Jones says, that "At St. Sebastian, the sappers finding the fire from the place very slack, contrived to push on the approaches more rapidly than usual, by a mixed nature of flying and full sap; that is, the sappers advancing on their hands and knees, placed one empty gabion after another, till a small row was formed: then two or three sappers placed themselves behind the empty gabions at good distances from each other, and sitting at their work, each formed a small hole for himself, and with the earth from the excavation filled the gabions in his front; after this, the sappers severally worked towards each other, till the whole row of gabions was filled and a trench formed along their rear. This mode of proceeding would probably facilitate the reduction of a small

second parallel need not be of such an extent as the first; and it is customary to protect its extremities by forming redoubts to contain a few pieces of light artillery, and a strong detachment to repel sorties: the rear faces of such redoubts not being exposed to the fire of the place, need not be of so strong a profile as the front faces:——Instead of a redoubt, the extremity of the second parallel may be continued in a defiladed curve to the rear to join the first parallel, as seen in Plate VII.; which has the advantages of shutting in all the ground between the parallels, and of giving an additional trench of communication, which may prove of importance in reinforcing the troops in the second parallel, if attacked by a strong sortie. If the defence be not very active, neither of these methods need be resorted to, but the extremities left *en l'air*, or open; terminated at the points 43 and 46, so as to be clear of the fire of the batteries, No. II. and VIII.

256. If the ground between the first parallel and the place be level, the second parallel will not interfere with the fire of the ricochet batteries on the first parallel: for the guns being fired with an elevation, the second parallel will be nearly under the trajectory or highest part of the curve, described by the flight of the shot. But should the localities of the ground cause the second parallel to mask the fire from the batteries on the first, fresh batteries must be constructed in corresponding situations, and for like purposes, on the second parallel; and the guns removed into them. The dotted outlines marked 2, 4, 5, 5′, 6, and 8, indicate the positions of the new batteries to receive the ordnance from batteries II, IV, V, VI, and VIII. If necessary, the batteries for direct fire must also be removed to the second

detached work, the artillery and musketry of which was well kept under, but would not be generally found practical under a smart fire."

parallel, from which the practice will be much more powerful and correct. The second parallel being at 300 yards from the defensive works, it is probable that some of the short faces or flanks (the prolongations of which could not be distinctly seen from the first parallel,) may be discovered and their crests prolonged, and marked: such as the flanks of the bastions, the faces of redoubts, &c.; for example, in Plate VII., the right flank of bastion B and the left flank of bastion A, (which have finally to be silenced by the counter-batteries XX and XXVIII), might each be enfiladed by an 8-inch howitzer from batteries 48 and 47 *in* the second parallel. It is true that short ramparts and parapets are difficult to enfilade; but as each of these flanks is 50 yards in length, an occasional shell bursting from batteries 47 and 48, against the defensive guns, would help materially to injure them, and aid in their final reduction. Under all circumstances, the fire from the batteries must be unremitting, and amply sufficient to keep under the fire of the defences; for all the trenches beyond the second parallel are formed by the sap, which cannot be conducted against the fire of artillery.*

257. As the approaches draw nearer the attacked place, it becomes more and more difficult to defilade the branches of the zigzags, especially if the front of the

* At the siege of the citadel of Antwerp, in the winter of 1832, it became necessary to move the batteries from the first to the second parallel, on which the French general of artillery, Neigre, observes in his report, that "The disarming of the batteries in the first, and arming of those in the second parallel, was gradually performed, so as not to render sensible the diminution of fire during this operation: and that since the opening of the trenches on the night of the 19th of November (to the 11th of December), 19 batteries with platforms for 138 pieces had been constructed." Musketry loopholes of sand-bags are made along the crest of the second parallel, and all the works in succession as they advance, in order to reply to the musketry of the defenders.

enemy's works be extensive (or on a high polygon), without making the alternate angles inconveniently acute. It then becomes necessary to advance in a straight line by the *double sap*, Chapter VIII. The zigzag approaches, either by the flying or single sap, are pushed on from the second parallel, till they reach within 150 yards of the crest of the glacis of the place: here it becomes necessary to establish *demi-parallels*, or portions of parallels, to contain strong guards to protect the further progress of the work, and to answer the enemy's musketry, which is done through loopholes, formed by sand-bags. These demi-parallels are either straight or formed in a curve, extending so as to embrace the prolongations of the covered-way before the attacked works; see Plate VII; at each extremity of the demi-parallel there is a battery of one howitzer (battery X to XV), on the prolongations of the branches of the covered-way, in order to enfilade and ricochet them; and to keep down their fire as much as possible, by tearing up their traverses and clearing their banquettes, these howitzer batteries are sunken; that is, they are formed in the demi-parallels, in order that they may not mask the fire of the batteries in their rear. It may be observed, in Plate VII, that there are six branches of the covered-way crowned from T to U. In order to enable the assailants to do this, the defenders must be entirely driven out of the covered-way, and those howitzers at the extremities of the demi-parallels are for the purpose of completely clearing the terre-plein of the covered-way.

258. From the demi-parallels the sap is continued on the three capitals as far as it can be carried in a zigzag direction; but when the zigzags become too multiplied, the double sap must be resorted to, as seen in Plate VII; when the saps on the three capitals have reached the foot of the glacis, they break into single saps, and deploy to the right

and left to connect their work together, to form the *third parallel.* In all this work the guard of the trenches must follow close upon the sappers, and that in the demi-parallels and second parallel must be prepared to meet sorties that may now be expected to attempt to destroy or retard the work, so near to their covered-way. As soon as the third parallel is sufficiently advanced, batteries of small mortars or pierriers are placed in it wherever they may be required, in order to shower into them grape of hand-grenades (see Plate VII, batteries XVI to XIX): so that with the fire of the mortars and howitzers in the demi-parallels, and the batteries on the first parallel, the defenders may be quite overpowered. These batteries for 5½-inch brass mortars are placed on the capitals of the re-entering places of arms, which places they are intended to shell as well as the flanks of the bastions. A strong guard occupies the third parallel, to keep under the musketry fire of the place, and sustain the workmen. The foot of the glacis being about 8 feet beneath its crest, 19 feet beneath the crest of the ravelin, and 22 feet below the crest of the enceinte, the third parallel will not mask the fire of the artillery behind it. It now becomes necessary to seek for the defensive mines, for it will be needless and destructive to attempt to push on the sap, until the ground below has been secured.

This Essay does not enter into any details beyond those given in Chapter VIII. The reader must refer to the larger "TREATISE," Chapter XIV, in order to get acquainted with mining operations.

259. The next operation is the crowning of the covered-way, for the purpose of establishing breaching and counter-batteries. It is for the general commanding to decide upon whether this is to be done "*de vive force,* or by the more slow and safe mode of sapping. The motives that usually

lead to the former are of a political nature, that render it essential to abridge the duration of the siege. If these motives should be pressing—if the feeble fire of the besieged announces his weakness and discouragement—if it be seen that his redoubts and retrenchments in his places of arms are silenced and dismantled,—the attack *by storm*, or "*de vive force*," may be adopted, and the lodgment or crowning of the covered-way made by the flying-sap. But, if the besieged has redoubts and retrenchments in good order, in his places of arms,—if there be good reason to suppose that the enemy can run up his remaining guns from behind protected traverses upon his barbettes, and shower canister and musketry upon the covered-way and glacis—and if, above all, it should be of little importance to hasten the fall of the place by one or two days, such an attempt should not be hazarded; which, if it does not succeed, will only retard the progress of the siege at a heavy loss of valuable lives; and if it does succeed, it will be too dearly purchased by the sacrifice of many gallant soldiers.

260. *To attack the covered-way and to establish the lodgment "de vive force."* After the third parallel has been completed, a great quantity of materials, such as gabions, fascines, sand-bags, entrenching tools, &c., are to be arranged on the top of the reverse slope of the parallel. Good and numerous steps are made in the various parts of the parallel, by layers of fascines and hurdles well picketed down, so that the troops can move out by them in regularity: the parallel to be lined with riflemen, who, with all the batteries, keep up a heavy fire till the moment the troops issue from the parallel. The close of the day, while still dusk, is recommended as the most suitable time for the operation, as there is then sufficient light to prevent confusion, and the work has the benefit of the approaching obscurity. The storming party divide and march upon the

places of arms, and especially assault the re-entering places of arms, entering the covered-way by the openings previously made in the palisades by the enfilading batteries; some of the party are armed with hatchets to force the barriers and palisades, should they not have been destroyed. The active fire of the batteries will have nearly cleared the covered-way of the defenders, and the storming party drive the remainder from their traverses, and keep possession of the covered-way; while the working party, that has closely followed, trace the lodgment along the salient places of arms, by ranging their gabions, parallel to the crest at 18 feet from it, filling them quickly with the soil of the glacis excavated in their rear, and cover is obtained as rapidly as possible by this means, and by the aid of sand-bags, fascines, bales of cotton, hay, &c.: thus, in Plate VII, the crest of the glacis at the salient places of arms, before the two bastions and the ravelin between them is crowned by the flying-sap, to as great an extent as time and circumstances will allow. Traverses must be made to prevent the work being enfiladed; and workmen must be told off to form a double flying-sap, to connect the lodgment with the third parallel: part of the storming party retire into this lodgment as soon as it can give them cover, and the remainder retire into the third parallel. From what has been said in paragraph 197, it is of great importance that there should be a very abundant supply of filled sand-bags, with active, well-instructed working-parties to carry and build them, in such an operation as this.

261. *To advance regularly by the sap to crown the covered-way.* If the attack has been successfully carried on, and the weather has been such as not to fill the trenches with water and to delay the work, it is customary to calculate upon completing the third parallel about the *twelfth* night after opening the trenches; and if the safe process of

sapping regularly up to the crest of the glacis be followed, instead of the attack *de vive force;* it may begin about the twelfth or the thirteenth night, by striking out single saps, (Plate VII,) about 30 yards on each side of the capitals of two ravelins and the bastion attacked, and carrying them forward in the curved direction therein shown, so as to meet about 20 yards up the slope of the glacis; these *circular portions*, S, S, S, are defiladed from the fire of the place by their curved shape; and from them, double and direct saps, with proper traverses, are carried forward, till they arrive within 20 feet of the crest of the glacis: double saps have also been pushed forward at the same time from the third parallel along the capitals of the re-entering places of arms, until they reach within 20 feet of the crest of the glacis: here all the double saps break into single saps, and proceed to connect their work together, and to extend their lodgment from T to U, forming traverses, as seen in the tracing, to shelter the trenches from reverse or enfilading fire. The length of these traverses depends on the projection of the neighbouring works still manned by the enemy.——Formerly, during the process of this advance from the third parallel to the crest of the glacis, the assailant constructed great elevated masses on the glacis, in order to obtain a musketry fire from a superior height to the covered-way: these masses were called *trench cavaliers.* They were made at 30 yards from the crest of the glacis, (see the dotted circular portions behind batteries XX and XXI: this distance of 30 yards, or 90 feet, being rather greater than men can throw hand-grenades.——A trench cavalier is formed by a series of gabions, probably three or four tiers, one over the other, in order to obtain a height sufficient for the men placed behind it to see into the covered-way; this huge profile is very difficult to construct, having usually a total height of 12 feet, and requiring so great a quantity of

gabions and fascines, and involving in it so much labour and time, as well as serving as a conspicuous mark for an enemy, cannot be recommended. The defenders, however, must be driven out of the covered-way, ere the assailant can form his lodgment on the crest of the glacis; and the object of the trench cavaliers is to give so commanding a position as to enable an assailant to look into and drive the defenders out of the covered-way: but this can be done more effectually by the fire of artillery than by that of musketry. Each branch of a trench cavalier having usually a length of 36 feet, cannot give a stronger fire than 12 men from its crest; whereas an 8-inch howitzer, placed in a parallel or in a demi-parallel, in order to enfilade a branch of a covered-way, projects at each round a spherical case-shot, carrying 380 musket bullets. Moreover the branches of the whole of the covered-way, from T to U, Plate VII, having been enfiladed by the constant fire of the first batteries from their first establishment, and by a succession of common shells and spherical case, as well as being exposed to a vertical fire of shells, and subsequently from the demi-parallels, there can be no need of such works as trench cavaliers; which, in addition to all their other defects, would mask the artillery practice from the batteries in their rear.*——As soon, however, as the saps reach the crest of the glacis, the fire of the distant batteries must be very carefully conducted. The range of the shells from the mortars being accurately known, their fire can be carried on with little interruption: also from the whole of the ordnance of batteries No. I, III, VII, and IX. But the rest of the guns must fire only according to their opportunities and circumstances.

262. *The counterbatteries*, XX, XXI, XXVII, XXVIII,

* At the siege of the citadel of Antwerp, in 1832, no trench cavaliers were constructed; but howitzer and vertical fire, especially from a great number of Coëhorn mortars, was much multiplied from the foot of the glacis.

Plate VII, are to counterbatter such of the remaining defences that may be still active upon the flanks ; these flanks, however, will have previously suffered greatly from the enfilade fire of the guns, howitzers and mortars, from the various parallels. It is absolutely necessary completely to overcome the flanking defences of the place that the ditches may be crossed in security. The traverses on the branches of the covered-way that mask the fire must be either cut or blown away, that the guns may have a free range. In those parts of the crowning of the covered-way, where it is necessary to place batteries of artillery, the trench in rear of the parapet should have a breadth at bottom of 24 feet, but elsewhere not more than 12 feet (unless earth be required to construct the parapet, which from the slope of the glacis to the rear is likely to be the case); and traverses must be constructed wherever it may be necessary, in order to cover its interior from flanking fire, or to afford shelter from bursting shells. When batteries XX and XXVIII have silenced the flanks against which they fire, and beaten down the defensive parapets (as indicated in fig. 120), their fire can be brought to bear upon any retrenchments in the bastions A and B, and aid in their reduction. At the salient places of arms before the ravelin attacked, the counterbatteries XXIII and XXIV are constructed to silence the defences that flank the ditch of the ravelin : thus the besiegers obtain a full command of the ditches on the fronts attacked, and by keeping the fire of the defensive works under, the operation of crossing the ditches and taking possession of the breaches becomes a comparatively safe proceeding. The batteries XXIII and XXIV having obtained the superiority over the defences, become breaching batteries; and the ditch of the ravelin being entirely under their command, the besieger may descend into it, when it is dry, and sap along its bottom towards the breaches. The

counterbatteries XX and XXVIII, should take care to beat down the crest of the tenaille (between the bastions A and B), and ruin its parapet; else the defenders placed on this work would bring a powerful musketry fire into the ravelin, and upon the main-ditch at the time of assaulting the breaches.

263. *Breaching batteries*, No. XXII, XXV, and XXVI, are constructed on the crowning of the glacis opposite to such portions of the faces of the works as are selected for that purpose, in order to breach the revetments to make them fit either to assault or to carry the saps up their slopes. After breaching, should the soil of the rampart stand stiffly, large shells filled with powder, having suitable fuzes, thrown in, will act as fougasses and bring it down; the breaching batteries must be in action by night as well as day, to keep the enemy from stockading the breach, or rendering it impracticable. When the lower part of the revetment cannot be seen sufficiently from the breaching battery on the crest of the glacis, to make an effectual breach, it must be established upon the terre-plein of the covered-way.

264. The combined fire of these batteries on the crest of the glacis must uncover the interior of the enemy's works as much as possible, by destroying the parapets; and assisted by riflemen from loop-holed cover of sand-bags, &c., the enemy must be quite kept down. The defenders must have no rest; the unceasing, irresistible, and concentrated fire of fifty pieces of artillery from the first parallel, followed subsequently by the fire from the powerful howitzers on the demi-parallels, from the mortars on the third parallel, and lastly, from the counter and breaching batteries upon the crest of the glacis, will effect this; this fire also will be aided by that of the extreme batteries on the first and second parallels, and by the fire of the howitzer and mortars

on the demi-parallel and third parallel (but the fire from the ricochet batteries on the first and second parallels, will be greatly, if not entirely, masked by the crowning of the covered-way). This combined fire is of a nature so overpowering, tearing up and destroying everything opposed to it, that the operation of seizing the other works will be far less destructive than is, at first sight, imagined. It is calculated that by the *fifteenth* night the counter and breaching batteries can be finished and armed; and the descents into the ditches commenced opposite to the breaches.

265. *Descent into the ditch* (see *g l* in fig. 120 and fig. 123, Plate VII). This is by a subterranean gallery, whenever the counterscarp is sufficiently elevated to preserve a covering of five feet between the top of the gallery and the terre-plein of the covered-way: miners deem this the least thickness necessary, overhead, in driving a gallery in ground of ordinary tenacity, that the soil may not break in and render the execution of the work too slow and difficult; besides which, it is necessary to protect the top of the gallery against vertical projectiles. In the section of the gallery of descent, represented in fig. 123, the reader will observe that it is taken from *g* to *l*, of fig. 120, which is the most sheltered position that can be found in a direct line to the breach in the bastion B: hence, in fig. 123, the section shows a small depression in the glacis for 18 feet, after which the crowning of the glacis, appearing in elevation, would be as shown in this section; that is, the banquette of the crowning would be about $6\frac{1}{2}$ feet above the natural level of the ground, all along the left face of the re-entering place of arms at *g*.

266. The dimensions of the *descending gallery* (see paragraph 220) depend upon the use that is to be made of it: if artillery is to be used in reducing the inner works, the retrenchments, &c., and that guns have to be passed

through this gallery, it must be large enough for the purpose, that is, 7′ wide by 6′ 6″ high. If the gallery be only for the passing of troops to the assault of the breach, &c., less dimensions will suffice; viz., 6 feet 6 inches high by 3 feet 9 inches wide. The gallery usually opens at the bottom of a dry ditch, and at 15 or 16 inches above the highest level of the water in a wet ditch. It ought to be driven as much as possible in a straight line, since changes of direction are slow and difficult of construction, and render the communication less commodious: the base of the gallery should be about five times the height; (that in fig. 123, *a b*, is five times *a c*:) but it is not indispensable that this slope be uniform in the whole extent of the descent.——That portion of the gallery in fig. 123, which is open at the top, that is, the portion in rear of the mining-cases, is sustained and formed by blind frames. These frames, *e*, *f*, *g*, *h*, fig. 121, are placed on each side of the intended gallery, at about 1 foot apart: they are usually 5′ 4″ high and $2\frac{1}{2}$′ wide in the clear: two rows of these frames are placed parallel to each other at 4, 5, 6, or 7 feet apart, according to the width of the gallery. A roof is formed to this gallery by a set of corresponding frames that rest upon the top sills of the side frames, as seen at *l*, *m*, *n*, fig. 121: this section shows one side of this arrangement, or one row of the frames; the short ends of the top frames *l*, *m*, *n* (the little shaded ends indicating the sections of the long parts of the frames that cross the gallery at top). In fig. 123, *r b* shows the first frame, and these frames are carried on to *i d*, covered over at top with 3 layers of fascines; some earth; and then green hides of animals stretched over all, to prevent their being set on fire. When this blinded descent has advanced so far that a solid covering of 4 or 5 feet of earth can be obtained, a regular gallery is begun with mining-cases, as seen at *i d*, and

continued to *c*, where the miners break through the counterscarp revetment: the descent is commenced by excavating the sloping ramp *b i d*, fig. 123, and it is carried on until there is a sufficient mass of earth above to allow the regular mining-cases to be fixed: all in the rear of this is blinded. The sides of this blinded gallery, are also lined with fascines, to keep the earth from breaking in. Fig. 122 shows an elevation of this descent at its entrance *r b*, the lines indicated at S being the tops of the frames and cases.——If the defensive ditch be shallow, or containing much water, it may be necessary to carry on the blinded descent to the counterscarp.——Work of this kind may be executed at the rate of 3 feet in 6 hours, in fair soil: 6 or 8 sappers being employed at a time; to be relieved every 4 or 6 hours.

267. In shallow ditches the gallery of descent would be driven under a traverse in the covered-way, in order to obtain as much cover as possible above the gallery, to protect it from vertical projectiles.

268. In examining figs. 121, 122, and 123, the reader will not fail to observe that the construction of this blinded descent, followed by that of a great gallery, all made of large weighty timber, requiring very expert sappers and miners,—most precise work, and that probably executed under the fire of a determined enemy—is an undertaking of great magnitude; and that it is therefore very important to lessen or abridge it: this may, in most cases be done, by such a powerful combination of offensive batteries on the crowning of the glacis, as to beat down all interior retrenchments, and thus render it quite unnecessary to pass guns through the gallery of descent in order to establish batteries in the captured works against interior retrenchments. If so, then the dimensions of the gallery, instead of being 7′ wide by 6′ 6″ high, may be reduced to 6′ 6″ by 3′ 9″ as specified in paragraph 220:

this will greatly lessen the difficulty of the operation by introducing lighter and handier timber (see Chap. VIII, paragraphs 217 to 221). Moreover, the slope of the gallery need not be so gentle as in fig. 123, it may nearly follow the dotted line *d c*, and may be begun without any blinded descent (as seen in fig. 54, Plate IX), or by deepening the trench of the original crowning of the glacis, and proceeding at once in the required direction with the common gallery cases.——The process of passing guns through a gallery of descent, taking them across a ditch, up the ruined rough slope of a breach, and forming a battery in the restricted space within a breached work, would be so laborious and occupy so much time, that, if possible, it should never be done. The commanding position on the crowning of the glacis enables the assailant, with the aid of mines, to *raze* the faces of the ravelins or bastions, to see the interior redoubts and retrenchments from his batteries, and effectually to silence and breach any remaining defences.

269. In all cases, when the miners reach the back of the revetment of the counterscarp, they pierce through the wall by forming an arched passage of the required size.—— It is usual to make recesses on each side of the extremity of the gallery behind the revetment, in which to collect materials for crossing the ditch : these chambers are most useful for the engineer, in the difficult operation of crossing a wet ditch.

270. When, however, the fire of the defensive works has been fully subdued and is quite kept under, the parapets destroyed, and that it is intended to assault the breaches as soon as they can be made, instead of these laborious descending galleries, three or four shafts may be sunk in the terre-plein of the covered-way, immediately opposite to the breaches, and charges lodged in chambers at their

bottoms; the explosion of these will throw in the counter-scarp, and join the rubbish to that of the breach in the escarp: the explosion being the signal for the storming parties to advance: *x*, *x*, *x*, *x* (opposite to the left face of bastion A), Plate VII, is intended to represent the space thrown down by the explosions.

271. *Passage of a dry ditch.* When the ditch is dry, this passage consists of an ordinary sap, pushed from the opening of the gallery of descent to the slope of the breach, as at *l*, bastion B, fig. 120, Plate VII, and, when necessary, it is carried on to crown the summit of the breach. In crossing a ditch protected by the fire of the counter and breaching batteries, the interruption to the work from the defences cannot be very vigorous, and a single sap will suffice, having its parapet on the exposed side. If it be intended to storm the breaches at once, no sap is required across the ditch.

272. *Passage of a wet ditch.* If the locality favours the draining of it, every means must be used to break the batardeaux to cause the water to flow away, if not altogether, at least in part; and should none of the batteries on the crowning of the glacis, or those formed in the covered-way, be able to see the batardeaux, these sluices must be sought for and destroyed by large shells; or, if possible, galleries for mining them must be driven from the nearest part of the establishment on the covered-way. Should the ditches be subject to the ebbing and flowing of the tide, the destruction of the batardeaux will at least secure to the assailants the advantage of having the ditches dry, or nearly so, for the periods of low tide; and thus facilitate the means of crossing, either by permitting the storming party to assault the breach at low water: or, if the slower and surer mode of making a causeway across be followed, the foundation of it can be more securely laid. If the assailant has

not the means of arresting the current of the water, or of draining or turning it, it becomes necessary to construct either a bridge or a causeway, with a solidity amply sufficient to prevent it from being carried away. This operation is one of the most difficult in the siege ; it is even impossible to execute it unless the defences of the enemy be totally ruined by a correct and well sustained fire from all the batteries. The dike or bridge, with its epaulement, is constructed with fascines, hurdles, joists, gabions, and sand-bags. When the water is stagnant, this work is conducted to the foot of the breach ; but when it is running, or can be made so, an issue is left for it at the foot of the breach, of from 18 to 25 feet, across which a float of rafts is thrown to complete the passage; and openings are left in different parts of the work or causeway to allow the free flow of the water.

273. *General Sir Charles Pasley's method of crossing a wet ditch.*—The following experiment was tried successfully at the Royal Engineer Establishment for Field Instruction, at Chatham, by order of General Sir Charles Pasley, K.C.B., F.R.S., &c. :—Two hundred large casks were prepared ; their heads taken out ; they were lashed by fours, end to end, so as to form hollow piers, about 18 feet in length, and of unequal diameters, in consequence of the unequal diameters of the heads and bungs. Each pier was launched in succession from a great gallery, representing that of the counterscarp in a regular siege. These piers had guys at each end, by which they were hauled round into their intended position, and there sunk by means of sand-bags. In this manner, a piece of water, representing a wet ditch, was bridged over by these hollow piers, with great ease and expedition. After which the intervals between the upper tiers of casks were filled with long fascines, where they rose above the surface, and others were laid over these at right angles, till a general level was obtained, when strong skids were

laid over all, and a 24-pounder, on a travelling carriage, was dragged through the gallery and passed along these skids to the other side of the water. This experiment was afterwards tried with full success in the Mast Pond of Chatham Dock-yard, where a very strong current was produced, much more so than could exist in the ditches of any fortified place. There was no perceptible depression in the bridge as the 24-pounder passed over.——The same experiment was tried with common gabions, lashed together, end to end, in the like manner; and forming hollow piers or cylinders, which being similarly sunk until they rose above the water, were covered with fascines and skids: this, also, bore a 24-pounder, causing a depression of more than six inches in the part over which the gun was passing. The gabions were very weak and old. These piers of casks were fastened as follows: on being placed end to end, staples were driven into each cask, about ten inches from each end, in three equidistant parts of its circumference; strong spun-yarn, connecting these staples, lashed the four casks together. Six or eight bushel sand-bags were necessary to sink each pier with ease, yet without making it sink rapidly. To get them into the water, they were launched on ways made of planks. (Each cask weighed on an average 141 lbs.) In making the gabion bridge, each pier consisted of four gabions lashed endways together, as the casks, by spun-yarn, at three equidistant points of the circumference: these were not loaded to make them sink. It was found, from the irregularity of their surface, that the second pier merely forced the first out from the bank to make room for itself; the third the same, and so on, until tiers of gabions connect the two scarps floating on the surface. On rolling other piers on the top of them, the lower ones sunk to the bottom, and fascines and brushwood were laid in the bites of the gabions to form a level surface.

274. On the completion of the passage of the ditch, the breaching batteries render the breach as gentle and practicable as possible either by round shot or shells, as required; a few brave and intelligent sappers glide up the breach and reconnoitre the interior of the work, under vollies of uncharged shells, and blank cartridge. Officers or intelligent non-commissioned officers should fully and strictly examine the breaches, especially at night: their reports of the interior defences or retrenchments, will probably determine the officer in command as to whether it is proper to storm the breaches, or to proceed to crown them by the sap, and construct batteries within them against the retrenchments. If there should not be any retrenchments behind the breaches, or, if they should be weak and imperfect, every necessary disposition is made for the assault of all works at the same time. If an enemy has no other resource than that of standing the assault, he should beat the *chamade*. This will be from the twentieth or twenty-fourth day from the opening of the trenches.

275. But if the ravelins have redoubts, and if the bastion be retrenched, it is necessary to carry on the attack by pushing a regular sap up the breach, and forming a lodgment within the work for the attack of the remaining defences in form.——The summit of the breach being gained, and a lodgment made upon it by the sap, the ulterior operations depend on the nature of the retrenchments. Should the ravelins attacked be provided with redoubts, the breaches in the adjoining bastions cannot be seized till the flanks of these redoubts that bear upon them are silenced; and when captured, batteries may be formed in their gorges, to aid the further operations against the enceinte.——In like manner, if the bastion be retrenched, the sap is carried up the breach, and a lodgment formed within the flanked angle,

the fire of which, supported by that of the batteries of guns, howitzers, and mortars in its rear, will surely overpower the remaining feeble defences, and enable the assailants to proceed to the assault, should the besieged risk this fatal proceeding.

CHAPTER XI.

ON THE ATTACK OF FIELD-WORKS.

ATTACK BY SURPRISE. STORMING PARTIES, &c. ESCALADING. REGULAR ATTACK BY OPEN FORCE.

276. There are two modes of attacking fortified posts or field-works: 1st. *by surprise*; 2nd. *by open force*. In both cases the assailant must have a thorough knowledge of the localities and defences: this can generally be obtained by spies, deserters, maps, and plans: also from the peasantry, especially such as may have been employed by the defenders as workmen or mechanics: all such information should, however, be taken with caution, and none fully relied upon that has not been confirmed by the personal observation of intelligent officers, or, in small detachments, by non-commissioned officers. A good telescope is an indispensable aid in obtaining information.——Should an officer charged with the duty of carrying an enemy's fortified post, be induced to attack it at night, his arrangements should be of the plainest and simplest character; for anything that is otherwise, is almost certain of failure from the confusion that darkness brings into all such operations.

277. An attack *by surprise*. The strongest and most formidable works have been carried by surprise and boldness, through the negligence and misconduct of the defenders: attempts of this kind will be regulated more by the latter consideration than the strength of the works.—— *First*. If the enemy has neglected the placing of piquets, videttes, sentinels, outside of his works, and other precau-

tions, indicating a state of carelessness or want of professional intelligence. *Second.* Should it be ascertained that he has neglected interior arrangements for the defence of the works. *Third.* Should his troops be raw, undisciplined, or his officers slovenly,—then a surprise may be successful; and with good troops, good arrangements, and a bold execution, it will probably be so.——To carry this service into effect, some such plan as the following must be adopted:—1. Be perfectly *secret* in your intentions until the moment it becomes necessary to communicate to others what they have to do. 2. Determine whether your troops are to destroy or to hold the work; give orders and make clear arrangements accordingly. 3. Divide your party properly; some for the real attacks, some for false attacks, to be turned into real attacks if the opportunity offers. A party of picked men with axes, sledge-hammers, crow-bars, bags of powder, of 20, 30, or 50 pounds each, with fuses prepared, and with gimlets to attach them to barriers, stockades, covered caponiers, &c., or to lay them down against such obstacles. Each party should know *thoroughly* what is its duty and object: and there should be a conventional sign or badge.

278. Perhaps the best time for assaulting a work is early in the morning, or just before the moon rises; as the previous darkness covers all the preparatory arrangements. If the assault be made at night, it has been recommended to intrust a few steady men with port-fires, in order to light them in the event of the assaulting party having to penetrate dark passages. Cold rainy nights are favourable for such operations, as sentinels are apt to seek shelter and to

* These bags should be waterproof. A failure has lately occurred in the North of India, in consequence of continued rain and snow having made the powder so damp that a bag attached to the gate would not explode.

become sleepy; and the noise of the wind and rain also prevents the advance of the assailant being heard.

279. In all assaults, whether by surprise or by open force, it is proper to divide the troops into—

1st. Storming parties.
2nd. Supports.
3rd. Firing parties.

The latter will seek cover as near the work as possible; and, on the appointed signal for the storming parties to advance, this firing party will spread itself out in extended order, to keep down the fire of the defenders; if possible, preventing any man showing his head above the parapet, and firing steadily into the embrasures, to slacken the service of the guns. If the attack be by surprise, the firing party may be small; and as this attempt would be made only in the event of the enemy being quite unprepared, no firing or noise of any kind should take place until the assailants are in the work and upon the enemy. The assaulting parties must be followed by the supports, as soon as it is supposed that they have overcome the first obstacle: the supports should be ready at hand, not too soon in following; but above all *not too late.*

280. Should escalade be necessary (as it almost always is), as many ladders should be prepared as can possibly be carried and used by the storming parties. When it is considered how slow a process it is to bring up ladders to the counterscarp, in order to descend by them into the ditch, then to cross the ditch and to rear the ladders against the escarp, and to mount them, it is evident that success will, in a great measure, depend upon the number of men that can mount at the same moment; in other words, upon the number of ladders. Fraises in the counterscarp, are more troublesome to overcome than on the

escarp.——A ladder beyond a certain length becomes unwieldy, and the rearing of it difficult. The distance from the foot of the ladders to the wall should be at least equal to one-fourth of their height. If the distance be greater, the ladders will be easily broken under the weight of the men mounting them; if much less, they will be so erect that the soldiers, as they ascend, must be continually in danger of falling headlong down. Ladders should always be at least one-eighth longer than the height of the wall to reach the top.——The scaling ladders introduced by General Sir Charles Pasley, used at the Engineer Depôt of Instruction at Chatham, are in pieces of 12′ 8″ and 7′ 6″ in length, fitting into each other with strong double iron sockets, and tied by stout ropes. These can be arranged for any length, and quickly adjusted. Ladders made of long spars are awkward to carry; especially if there be narrow sharp turnings in approaching the point of escalade: nor can long sound spars be always procured. It is desirable that ladders should be made of light tough wood: teak wood is too heavy. If a guy-rope be attached to each side of the ladder, they greatly assist in adjusting and fixing the ladder against the wall: the men told off for the guy-ropes should stand close to the wall, within the slope of the ladder: these guy-ropes should be fixed at 5 or 6 feet below the top of the ladder, to prevent their being cut by an enemy from the top of the walls. The total lengths of the ladders should exceed the height to be escaladed by 3 or 4 feet, in order that the men may step easily off the ladders on to the parapet or wall. Many failures have occurred from ladders being too short. It is desirable to have a pair of stout lifting bars, 3 or 4 feet long, with hooks, for each ladder. When an escalade is to take place, *be sure* to practise the men intended for the service thoroughly in carrying, in fixing, in ascending, and descend-

ing the ladders (descending, for going down a counterscarp; ascending, for getting up an escarp).——Always use as many ladders as possible: if there be a counterscarp to descend, leave half the ladders there, while the other half are used against the escarp, that no time may be lost. Ascend the ladders together, on as large a front as possible.——When an escalade is opposed by an enemy, take care that a good firing party covers the escalade, with especial directions to fire upon any work that may flank the ladders.——Avoid night attacks, except under peculiar circumstances: the example of gallant men is lost at night, whilst the timidity of some becomes infectious. Make all your arrangements under the cover of darkness, and assault as the day breaks.——The bamboo, which grows so abundantly in India, makes excellent scaling ladders. Those of the largest size, being 3 or 4 inches in diameter, sufficient for lofty escarps, are not always procurable in the required lengths; but two or more such bamboos may be bound together securely, with the step bars not let into holes, but lashed on, either single or double, at intervals of 9 inches apart. The hollow bamboos being very light and portable (thus strengthened two or threefold,) make very good ladders, without being too heavy to be carried and raised.——It is doubtful whether any ladders could be manageable of a length suitable for an escarp of 35 feet (*i. e.* of about 40 feet of one continued length of ladder), of a strength capable of bearing the weight of a number of men crowding up, as is usual with storming parties: hence 35 feet of revetment has been assumed as beyond escalade height. Cases, however, doubtless, may occur, in which it may be necessary to carry such works by assault; and has not unfrequenly been done in India, where, especially in hill forts, the escarp is considerable; and in such cases (more particularly should the ladders be strengthened

to the utmost consistency *with their being kept portable,*) every additional support in the way of prop-stays and guy-ropes, &c., should be supplied.

281. *Regular attack by open force.* In well flanked and formidable field-works defended by good troops properly commanded, it would be highly imprudent to attempt to carry them by storm; for until the flanking defences are greatly injured, and good openings made by artillery for the assailants to gain an entrance, it would be an unwarrantable waste of life to try to force such posts. (Of course we do not speak here of the assault of strong and fortified positions occupied by armies: such, we know, have been taken, or rendered useless, by the superior strategy of an assailant; but we speak of the minor operations of detached bodies of troops.) To proceed against a well fortified post, the principles of a regular attack must be partially followed.—— These principles have been already explained in Chapter XV. The attack of permanent works has been referred to, in order to show *the principle* upon which all well flanked formidable works, defended by good troops, should be attacked: namely, the construction of a succession of good trenches, to contain strong guards to meet sorties and to reply to the musketry fire of the defences; of batteries of artillery, to enfilade and subdue the defensive artillery from a distance, to dismantle the parapets by a fire of shot and shell; to sweep their terre-pleins; to establish breaching batteries, to make openings fit to assault; and, finally, to blow in the counterscarp by mines, in order to join the rubbish upon the opposite sides of the ditches, as a path for the assaulting parties.——In most cases, however, these operations may be greatly abridged, although the principles must be adhered to. In nearly all fortified villages or posts, some of the walls or defensive stockades, &c., can be seen from a distance down to their very bottom, and therefore

breaches can be made without advancing the batteries within the musketry range of the defences (for gunners suffer greatly from a good steady musketry fire into the embrasures). Nor would it be necessary, in most cases, to carry forward the trenches or saps close to the walls; and as many walls and barriers are without ditches in front, and are open and seen from a distance, the breaches can be effected at from 400 to 800 yards, and can be reached by the storming parties advancing over the intervening space between the trenches and the breaches; provided this space is not too great, and that the defensive parapets are dismantled, so that the assaulting columns shall not be exposed to a heavy fire in advancing to carry the breaches. Their success depends on the breaches being quite accessible, their reaching them in perfect unbroken order, and their being well led on by able officers.

282. Take fig. 96, Plate X, as an example of an attack against the fortified village described in Chapter IX. The figure shows at once that such an attack has been expected and well provided against. The streets have been closed up with musket-proof parapets; the houses, in flanking positions, loopholed; lower-doors and windows all built up; every aperture and opening into the village has been closed by parapets constructed of casks, *c*, *c*, *c*, and with ditches, *p*, *p*, *p*, and lines of stockades, *r*, *r*, *r*, and abattis, *x*, *x*, *x*, giving additional strength to the fronts the most open to attack; the river and inundation covering the other sides. The bridge, it may be inferred, would be mined and ready for explosion after its covering lunettes are forced; and even, independently of this obstacle, so well flanked is the tête-de-pont by 4 pieces of artillery, that to carry the bridge might be expected to involve a heavy loss to the assailants, even if successful. Suppose then that the possession of this village is considered necessary by a field detachment,

limited to light troops, with one field battery of foot artillery, as at present armed with five 9-pounder brass guns, and one 24-pounder howitzer, and with an ample supply of reserve ammunition. The key to the whole position, it will be seen, is the keep, K; and the readiest point from which to assail it appears to be along the left bank of the river, which accordingly is selected for the attack. The field battery is opened at B, at 350 or 400 yards' distance; *i. e.*, beyond the effective range of musketry from the village, to lay open the flanked angle and destroy the flanking defences of the temporary bastion or redoubt *c*; under cover of which fire a running sap is thrown up by the troops, D, D, with a musketry-proof parapet only, and with a return capable of being converted into a field-piece battery E, to which position the guns should be advanced during the night. The stockade, *r*, *r*, *r*, being breached, and the lower portion of the outer wall of the keep, *e*, *e*, well laid open to view, the artillery are then advanced to the battery, E, and a concentrated fire by salvos directed to the spot. Supposing the wall to be of sun-burnt brick or mud, the usual kind found in Indian ghurries or village keeps, such as it is difficult to make an impression upon by round-shot alone, shells filled with gunpowder should be used, so soon as any impression could be made by their penetration. A few rounds would suffice to lay open the inner keep, against which the combined fire of the whole battery should be directed, and kept up until promising to be soon effectively breached: when, leaving four 9-pounders to complete the breach, the remaining two pieces, viz., one 9-pounder and one 24-pound howitzer, should then be removed to F, to scour the flanking defences by an enfilading fire during the advance of the assaulting column, A, which debouches from the protected line, D D, preceded by scaling ladders and pioneers to make sure work

of the breach, to overcome any unforeseen obstacles, and covered in the advance by light infantry skirmishers, *s*, *s*. The above presupposes that the defenders' guns in position have not been removed to support the defence of the keep, and that this post once carried decides the fate of the place. Should, however, the possession of the village be still further disputed, a lodgment must be effected in the keep, and a flying-sap, *g*, *b*, should connect it with the breach; and from the keep the artillery would speedily subdue the rest of the defences. This mode of attack would be preferable to a division of the artillery into small and comparatively ineffective batteries; and the use of shells, in the way proposed at such short ranges, is strongly recommended. From their lightness, they, of course, have not momentum sufficient to penetrate, at long ranges, into very hard and tenacious walls; but at close quarters their explosive effect in shattering a wall is hardly to be conceived; and in completing a breach they prove a formidable obstruction to any attempts to retrench the breach, from the incessant shower of splinters from the shells. ——The reasons for selecting this particular point for attack are, that the river covers the left flank of the assaulting columns; the stockades, *r*, *r*, *r*, on this side, are more easily breached than parapets; the concentrated fire of the guns will have silenced all opposition from the flanking defences that would fire upon the approaching columns, and cover their advance. It is presupposed that the keep, K, is the commanding position and key to the other defences; and it is, therefore, obviously desirable to concentrate all the available means and resources of the assailants to its reduction, without throwing away fire unnecessarily on the other portions of the enceinte. The three breaches, *e*, *e'*, *e''*, are conveniently near each other; and, if requisite, the flying sap and trench, *g*, *b*, would effectually protect it from surprise after securing

possession of it.——Behind the trench, D, parallel to the river, the assaulting column, A, is formed, with its support, Z. The smaller false attacks with their firing-parties are marked on the two other fronts of the village, *s a, s a.*

283. Light troops should be accustomed to place themselves quickly under cover. On service, they soon learn to take advantage of heaps of rubbish, stumps of trees, hollows, &c.; but, in the neighbourhood of a fortress, the ground around which is previously levelled, so as to afford no cover for an assailant, they must be taught to dig pits so as to lodge themselves as near as possible to the ramparts. Fig. 34, Plate VIII, shows a plan and two sections of pits which light troops should be expert in making; having good loopholes of sand-bags, as seen in these figures. Finished dimensions of this kind, however, cannot be always attended to: the object is to get cover, and each man digs a hole for himself as rapidly as possible. Good light troops thus lodged around an attacked work, have a great effect in subduing the defensive artillery, by firing steadily into the embrasures.

284. If there should not be any artillery to destroy the flanking defences, such as caponiers, reverse galleries, &c., a bold attempt must be made by night to hang bags of powder against them, with long powder-hoses, or Bickford fuzes, in order to ruin them by the explosion. This can be done by active officers or non-commissioned officers approaching silently and in darkness, so as to place the charge against the object to be destroyed, or as near as possible. In bold attacks by daylight, a pole may be fixed on the axletree of a light limber carriage, carrying a bag of powder at its extremity, manageable by a rope, which carriage can be run up to the counterscarp (having a shield of bags of hay or cotton), and the charge dropped upon the required

part, and fired by a lock or by a hose. Should there be an abattis, if possible get round its flank; if not, set it on fire with pitched fascines and howitzer shells, or haul portions of it away by night.——Trap-holes and small ditches must be filled in by bags of hay, bundles of fascines, light bales of cotton, &c.——Stockades, barriers, palisades, fraises, chevaux-de-frise, to be destroyed by an enfilading fire of howitzer shells; or in closing with them, by bags of powder. To ensure success in all these matters, sufficient means, perfect arrangement, thorough explanation, boldness, and rapidity of execution, are indispensable.

285. The reader has now had placed before him the principles of defending villages; of entrenching military posts and positions; and also the best methods of attacking such defences. But it may be observed, that however desirable it may be to fortify a military position with all care and skill, yet a proper judgment must be exercised as to means that an assailant may bring against it. If an enemy has overwhelming means for reducing field-works—if he has a good battering train at command before which common field defences must yield and crumble to pieces—then it becomes a question whether the means and time of the defenders should be expended in fortifying a position that cannot retard the progress of, or resist, a powerful enemy; and whether these available defensive means could not be better applied in other ways. As an instance of what is meant, we proceed to quote one case from the history of the Peninsular war, where the contending parties were the active armies of England and France, under the Duke of Wellington and Marshal Marmont respectively: the latter able commander bestowed great pains on fortifying the strong suburbs of Salamanca, which were found incapable of standing before the siege train of the Duke of Wellington.

286. Salamanca (in Spain), in 1812, contained about

18,000 inhabitants; the city is situated on the river Tormes. It served as a depôt for the French army. Its position, its numerous great edifices, convents, hospitals, and fine stone bridge, rendered it a good depôt, and a suitable place for defence. Napoleon wrote thus to Marshal Marmont, commanding the French army of Portugal—"Make Salamanca your head-quarters; work with activity to fortify the city; employ 6000 troops and 6000 peasants; arm the works with your siege train. *Appuyed* on Salamanca with your artillery and magazines, your army of 40,000 men is unattackable." Marshal Marmont proceeded to execute the orders of the French Emperor. Three large buildings, viz., St. Vincente (A), San Gayetano (B), and La Merced (C), see fig. 93, Plate X, were fortified. They stand on the bold bank of the river Tormes, at the angle of the town that rests on the river, where there is a fine stone bridge. The convent of St. Vincente is the largest of the three. A small front (to the left) having a dry stone escarp and counterscarp, was built; on the curtain of which four field-pieces were placed. All the houses in front were demolished, and their ruins formed a kind of covered-way and glacis, which was kept as high as possible, in order to cover the escarp: the wood of the demolitions made abundance of good palisades, barriers, blinds, chevaux-de-frise, magazines, &c. A lunette in masonry, pierced with two rows of loopholes for musketry, covered the gate on the left of the front, and flanked the old town wall on both sides.——On the east, a strong facine battery, *c*, having a line of inclined palisades in front, was made at a re-entering angle of the convent walls, to flank the ravine immediately below, and also the plateau of San Gayetano. A barbette battery at *f*, for four guns, was established more to the right, also to look upon the Gayetano, and to take in reverse the foot of the heights along the Tormes up to the bridge. Upon the

south side, the scarped bank of the river rendered attack extremely difficult; still several batteries were prepared to command the river and the ground on both sides.——In the interior of the convent, the church was pierced for two rows of loopholes, and made into a redoubt, separated from the other buildings by a ditch: this church held the powder-magazine, blinded and covered with sand-bags. The garrison were lodged in the cloisters, where the hospital and provision magazines were prepared. Minor arrangements of loopholes for musketry, turning gratings and windows into embrasures, separating the buildings from each other, &c., completed the defensive properties of the convent of St. Vincente. It was 400 yards from the bridge; and was separated from the opposite plateau by a deep ravine. On this opposite plateau the redoubt La Merced, C, was formed of part of the College del Rey, which was separated from the neighbouring houses; the buildings were loopholed; the roof was raised, blinded, and covered with earth. This redoubt was 200 yards from the bridge, which it fired upon obliquely with two guns.—— The second redoubt on this side, called San Gayetano, B, was nearer to St. Vincente. The vaults of the cloisters of this convent were destroyed, and the walls served for the sides of the ditch, which was flanked by reverse galleries in the counterscarp; the great stone ruins around were formed into a glacis; the roofs were raised, blinded, and covered with earth. This redoubt was armed with four light guns, protected by a parapet of sand-bags placed upon the convent wall.——The ground around these two redoubts was so covered with masses of ruins and great stones, that it was impossible to sap in it. A communication between St. Vincente and San Gayetano was made by a little road across the ravine Tanneries, along the old town wall. These works were executed in three months, by four companies of

sappers and between five and six hundred infantry. When Lord Wellington advanced upon Salamanca, and the city was evacuated by the French troops, they left a garrison, for St. Vincente and the two redoubts, of 600 infantry, a company of artillery, and 25 sappers; amounting in all to about 800 men. These works were well conceived, and as well executed; most formidable against guerillas, irregular troops, or even regular troops, without a battering train; but subsequent events showed that they were not capable of withstanding the powerful fire of heavy shot and shells from battering guns.

287. In June 1812, the Earl of Wellington advanced to dislodge the French from the town of Salamanca, defended by the formidable works just described. Four iron 18-pounders, five iron 24-pounder howitzers, and some field artillery, were prepared to reduce these forts.—— Batteries L, D, and K, were prepared and armed with the guns named; a heavy fire from which, especially with hot shot to set the convent on fire, finally succeeded in reducing these strongholds; notwithstanding the advance and efforts of Marshal Marmont, with a French army of 40,000 men, to relieve these fortified posts, and which suspended the operations against the forts for a few days. The convents were successfully assaulted by the British columns on the 27th of June. The number of prisoners was 800; and 36 pieces of cannon were found in the forts, besides a quantity of stores and gunpowder. The loss, in the allied British and Portuguese army, amounted to 5 officers and 94 men killed; 29 officers and 302 men wounded.

288. *Observations.*—The result of the attack proves that these forts, although well planned and fully efficient to resist irregular troops, or a light corps with field artillery, were not capable of resisting more than two or

three days against heavy artillery, employed to beat down the walls and set fire to their interiors. There was a considerable delay and loss in their reduction, which was entirely owing to the want of a proper supply of ammunition. Two or three days must have subdued them, had there been an ample supply of ammunition. The French writer, Colonel Belmas, in his "*Journaux de Sièges*," says, "This little siege cost the enemy more than 600 men, retarded his operations ten days, gave Marshal Marmont the opportunity of concentrating his forces, which would *infallibly* have led to the destruction of the Anglo-Portuguese army, *but* that King Joseph was not obeyed, and each general in chief acted independently, and thus robbed the French forces of that unity of action so necessary to obtain victory." The English writer, Colonel Sir John Jones, in his Journals of Sieges, remarks, "Surely the lesson the French had so recently received in the capture of Rodrigo, ought to have made them hesitate before they deemed such posts of a nature to risk the loss of 800 men in their defence when opposed to a regular army."

APPENDIX [A.]

ON REMBLAI AND DEBLAI.

[Referred to at page 86.]

In square redoubts, or works having salient angles, it is to be observed that if the areas of the sections of the parapet and ditch are made nearly equal, there will be too much earth; this is easily understood by referring to fig. 83, Plate X, which represent a profile of a parapet, with a plan underneath, having a salient angle: let the area of the profile of the parapet *a*, be 45·5, and of the ditch 40 square feet: let *a* be the centre of gravity of the mass of the parapet and banquette: *b* the centre of gravity of the excavation. The solid contents of the portions shown in plan will be equal to the areas of these two sections multiplied into the distance traversed by their respective centres of gravity, Now, that of the parapet, *a' a' a'*, is equal to 29½ feet, and that of the ditch, *b' b' b'*, is 44 feet; hence 45·5 feet × 29½ feet = 1342 cubic feet for the parapet: and 40 × 44 = 1760 cubic feet for the ditch: that is, the ditch gives 418 cubic feet more than is required for the parapet. Were the angle of the plan re-entering, instead of a salient, the result would be reversed; and an officer charged with the construction of a work must calculate, before he begins his excavation, what should be its amount, in order that he may have neither too much nor too little earth for his parapet.

In the figures under consideration, we assume 8 feet as the depth of the ditch; what then should be the width, in order to furnish the necessary quantity of earth required for the remblai? If 1342 cubic feet, the quantity needed, be divided by 44, the length of the path of the centre of gravity of the ditch, it will give 30·5 square feet as the proper area of the section of the ditch capable of yielding the necessary remblai: this section in fig. 83 is a triangle; and as the area of a triangle is equal to

[illegible] the perpendicular [illegible] therefore [illegible]

at 8 feet, and the slopes at a base of one-half the depth. The first process is to find a width for the ditch sufficiently near the truth to allow the plan, fig. 94, to be drawn. For which purpose, add the areas of the parapet and glacis together

$$103{\cdot}5+12{\cdot}375=115{\cdot}875,$$

which divide by the depth of the ditch,

$$115{\cdot}875\div 8=14{\cdot}484 \text{ feet,}$$

which will be the mean width of the ditch, or $z\ y$, fig. 95: then

$$14{\cdot}484+4=18{\cdot}484=\text{width at the top; and}$$

$$14{\cdot}484-4=10{\cdot}484=\text{width at bottom.}*$$

But in considering fig. 94, we see that there are three salient, and only two re-entering angles, and that the path of the centre of gravity, H, of the ditch, exceeds that of the parapet, G: hence, as an approximation, the above dimensions for the width of the ditch may be diminished, and we may try what 16 feet wide at top and 8 at the bottom will give. Let figs. 94 and 95 be drawn with these dimensions. The centres of gravity of the parapet, ditch, and glacis, must now be respectively found; this may be done mechanically by cutting out a piece of clean deal board, or pasteboard, of equal thickness throughout, into three pieces of the dimensions of these three sections, with any convenient scale (the larger the better), then take one of the sections, say the parapet, hang it freely by any corner on a pin, from which pin suspend also a plumb-line, and mark where this line cuts the board: † then hang up the body by any other point, and where the plumb-line cuts the first line on the board, the intersection is the centre of gravity: this must be done with each piece; let G, in fig. 95, be the centre of gravity of the parapet: let a perpendicular from G meet the horizontal line, Q S: let H be the centre of gravity of the ditch; and I in the glacis.

In Cape's Mathematics, vol. ii, article 75, "Mechanics," there is the following rule:—(noting however, in the first place,

* Or let x=the width of the ditch at the bottom in fig. 95.

$8x+32‡=115{\cdot}875.$

$8x\ldots\ldots\ldots=83{\cdot}875.$

$x\ldots\ldots\ldots=10{\cdot}484$ ft.

† See Cape's Mathematics, vol. ii. "Mechanics," article 71.

‡ This number 32 is the quantity of square feet contained in the two triangular portions of the ditch in fig. 95.

that in a right-angled triangle, a perpendicular let fall from the centre of gravity of the triangle on the base, cuts the base at one-third of its length from the right angle; in rectangles and squares, a similar perpendicular will bisect the base. Now as all the parapets and ditches can be reduced to these figures, there is no difficulty in finding the points required.)—To find the centre of gravity of any body or system of bodies. Through Q, fig. 95, draw an horizontal plane, Q S; draw also vertical lines through the centre of gravity of each body, to meet the base, Q S; let the distance of these points be severally Ql' Qe' Qf' Qd' Qc' Qb' Qa'; then the distance of the common centre of gravity of all these bodies from Q, will be Q G.=

$$\frac{Ql'\times l+Qe'\times e+Qf'\times f+Qd'\times d+Qc'\times c+Qb'\times b+Qa'\times a.}{l+e+f+d+c+d+a}$$

that is

$$\frac{4\times 18+10\tfrac{1}{2}\times 54+12\times 6{\cdot}75+15{\cdot}5\times 3+15{\cdot}33\times 2{\cdot}25+18\times 12+21{\cdot}66\times 7{\cdot}5}{18+54+6{\cdot}75+3+2{\cdot}25+12+7{\cdot}5}=\frac{1179{\cdot}5}{103\ 5}=11.4\text{ft.}$$

the centre of gravity, G, from the point Q.

Again for the glacis, to find the distance of the centre of gravity from the point *O*, by the same process.

$$\frac{Om'\times m+On'\times n}{m+n}=\frac{1{\cdot}125\times 1+11{\cdot}25\times 6{\cdot}5}{12\ 375}\ or\ \frac{74{\cdot}25}{12{\cdot}375}=6\text{ft. } or\ O\ I$$

The figure of the ditch being regular, the centre of gravity must be in the middle line. Thus the paths of the centres of gravity become marked on the plan, fig. 94, by the dotted lines G, H, I: in this case, let them be as follows: G G G=345 feet: H H H=440 feet: I I I=502 feet: then 345×103·5=35707·5 cubic feet in parapet: 502×12·375=6212·25 cubic feet in glacis; hence

	35707·5
	6212·25
Total in parapet and glacis	41919·75 cubic feet.

Area of ditch, (8×8)+(8×4)=96 square feet×440=42240 cubic feet: that is, 321 cubic feet more than is required for the parapet.

A reduction of rather more than three square feet in the area would make the remblai and deblai balance each other.

The earth thrown up from the ditch will, at first, occupy a greater volume than it did before it was moved; calculated usually at $\frac{1}{15}$ or $\frac{1}{20}$ more bulk than in its compact original state; this increase of volume must be duly considered and calculated

upon, in the event of the work being constructed to hold out for a few days or weeks only: but as the excavated earth settles down in a few weeks in a compact state; and as, in the careful construction of good parapets, it is well rammed down as it is thrown up, it would not then be necessary to reckon on the increased bulk in works intended to stand for months or years.

This simple process, however, requires that the path of the centre of gravity of the parapet, of the ditch, and of the glacis, should be known, which cannot be ascertained until the plan be drawn, hence the approximation first stated becomes necessary.

The foregoing method will answer for general purposes, and in carrying it out, it is supposed that the constructor can always calculate on going to the depth that he requires in the ditch, and that the soil is of a tolerably uniform nature; which circumstances, it is well known, do not always hold true in practice; moreover, in planning field-works, which are usually placed on irregular sites, the slopes of the ground must be particularly examined and considered, before beginning the excavation, that the interior of the work may be thoroughly drained, and in doing this, it may often be necessary to cut away in some places, and to fill in in others, so that there may be earth to spare from the interior, to assist in the construction of the parapets, or otherwise; besides which, deductions may be made for embrasures, and additions for barbettes, traverses, &c.

In low ground, or even in elevated plains, care must be taken, particularly in the rainy season, by exact levelling, that the ditches of the works, the covered caponiers, the reverse galleries, and the posterns, are not below the general level of the water-courses and ponds around. Draining works well should be particularly attended to.

A labourer can remove one cubic yard, or 27 cubic feet, in one hour in easy soil: and he can keep working at this rate for eight hours.

In the construction of field-works, trenches, and batteries, &c., the workmen are placed at 4 feet, 4½ feet, or 6 feet apart, according to circumstances. At 4 feet, instead of 6 feet from each other, the time gained is not in proportion to the lessened distance; for the men are then crowded, and cannot use their picks and shovels with ease, and without the danger of injuring each other, more especially at night. Suppose that in excavating a trench, as in fig. 1, Plate VIII, the men are placed at 6 feet

apart, the calculation will be as follows:—the area of the excavation is 42 square feet, which multiplied by 6 feet=252 cubic feet; divide this by 27 cubic feet, it gives rather more than 9 hours for the time of excavating the trench in easy soil. If the soil, however, be difficult, the time may nearly be doubled, especially if the men are untrained. This is the profile usually given to the first approaches and parallels at a siege, which can rarely be finished on the first night. It may be commenced in general about eight o'clock at night, and the working party should be tasked to have at least one half of it excavated by daylight next morning, nor should they be relieved until this is done: for although it is customary in sieges to relieve the working parties every eight hours, this rule should not be acted upon, if there should be any want of activity in the workmen.*

The trench, according to fig. 1, should be completed by the [illegible] workmen, that is, by noon on the day after breaking ground. This is as much as can be expected even from good workmen well superintended, when it is remembered that half a foot of earth at night with interruptions from the enemy's fire, the whole material thrown up from this trench, being at five or six hundred yards from the place, and of great extent, will be a sufficient screen for the assailants.

[illegible] work has to be constructed by trained sappers, it should not, if [illegible] it could be done with great ease in [illegible] hours.

[illegible] however, takes place in these calculations, when [illegible] is formed by excavating a ditch in front of it, [illegible] is obtained. In defensive works, this ditch [illegible] and its depth is considerably [illegible] than in the trench just spoken of: and the workmen have much labour in throwing up the soil. In the construc-

[illegible]

tion of regular field-works in daylight, the men in the ditch may be placed at 4 feet apart. Take an example: fig. 7, Plate VIII, the area of the section of the ditch is 72 feet; then $72 \times 4 = 288 \div 27 = 10\frac{1}{2}$ hours: the depth of the ditch being 6 feet, able men can heave up the earth at one throw: and, even in difficult soil, this work may be completed in 18 or 20 hours.

But when the depths of the ditches reach their maximum, as in figs. 8 and 19, Plate VIII, scaffolding and stages of men will be required to throw up the earth, when the time required for forming the parapet will be very greatly increased, and when every 4 feet of work will probably require about 1 digger, 2 or 3 shovellers, 1 rammer, 1 builder, and 1 carrier, in all 7 men; and will take from 30 to 40 hours of daylight to complete.

With regard to batteries, especially offensive batteries at a siege, where the ditch is excavated for the purpose of obtaining earth for the parapet, rather than to serve as an obstacle, the depth is only made 4, 5, or 6 feet, from which the earth can conveniently be thrown up: hence the labour and time is less than in massive defensive works, and requires 10 or 12 men per gun: the solid parts of the parapets where there are traverses or mortars, as well as the epaulements and the traverses also, require respectively 6, 20, and 10, additional men for each.

Regularly trained sappers at the Chatham establishment, usually excavate, in easy soil, two cubic yards per man per hour; and in difficult soil, one cubic yard in an hour. But such trained men are seldom to be had in ordinary cases, and it is best to calculate for what can be done by men of the line and common labourers, at the rate of one cubic yard per hour in easy soil, or in two hours in difficult soil.

Suppose the excavation to be equal to that in fig. 5, and as applied to fig. 11, Plate VIII, which represents the plan of an elevated battery, the guns being at 18 feet asunder: the area of the section of the ditch=126 feet$\times$18=2268 cubic feet, or 84 cubic yards, and suppose this is sufficient to complete the battery with its traverses and epaulements.

With capable sappers, allowing 4 diggers for every 18 feet, we have $84 \div 4 = 21$ cubic yards per man; then $21 \div 2$ cubic yards per hour$=10\frac{1}{2}$ hours, or the time taken in executing the work under *the most favourable circumstances of men and soil.*

But in unfavourable soil, with partially trained men, with interruptions from weather, and an enemy's fire, double this time

at least must be allowed; and it is as much as can be expected, if an elevated battery, under these circumstances, be executed in twenty-four hours of work: very little work can be done during daylight in the first batteries of a siege, while the enemy's fire is still vigorous and unsubdued.

Let us now apply these remarks to a specific case:—

See fig. 80, Plate X. Let the pontoon bridge represented in this figure be 200 yards long (or, in other words, the river 200 yards wide at this place): and let this bridge be protected on the right bank by the works traced as on this figure. The outer line of works to consist of a trench and parapet, as seen in fig. 1, Plate VIII; the inner line to be formed of a parapet and ditch, as seen in fig. 19, Plate VIII, the ground being considered favourable for defensive works of this description. Four field-pieces and 700 men are allotted for the defence, and for the construction of these works; the 4 guns and 50 men to be on the left bank; 650 men to construct and occupy the works on the right bank of the river.

Let the area of the section of the trench, in fig. 1, be 42 square feet, and the length of the line traversed by the centre of gravity of *a b e*, fig. 80=1620 feet, the quantity of earth to be excavated for this work=1620×42=68,040 cubic feet, or 520 cubic yards nearly.

Let the area of the section of the parapet of the inner line of works (corresponding with the section in fig. 19, Plate VIII, be 147 square feet, and the path of the centre of gravity of *e d f*, fig. 80=780 feet, the quantity of earth to be excavated=780×147=11,4660 cubic feet: or 4252 cubic yards.

Of the detachment of 650 men for these works, let 50 men be required (as carpenters) to construct strong stockades to shut in all the openings, &c., and let 600 men be available as labourers for excavating, forming the parapets, &c.: let this detachment be divided into three working parties of 200 men each; and to work 6 hours each relief during daylight, which we will suppose to be 12 hours each day. Let 30 men of each relief be put on the outer line to excavate the earth from the trench, and throw it up so as to form a rough parapet about $4\frac{1}{2}$ feet high.

$$\left.\frac{2520 \text{ cubic yards}}{30 \text{ workmen}}\right\}\text{—84 cubic yards per man:}$$

and allowing the soil to be such, that one cubic yard can be

excavated and thrown up by each man in one hour, and there being 12 hours of daylight, the period required to complete the trench work will be 7 days.

For the larger or inner line of works there remains 170 workmen in each relief: divide this party into 57 diggers, 57 shovellers and rammers, and 56 builders and carriers: then 4252 cubic yards (the solid contents of *e d f*, fig. 80) divided by 57 diggers=nearly 75 cubic yards per man; the shovellers, builders, &c., throwing up the earth and forming the parapet: and if the soil be easy so as to permit each digger to excavate a cubic yard per hour, then 74 hours of daylight will be required, or rather more than 6 days.

While the works are in progress on the right bank, the batteries for the guns, or any light works required on the left bank, will be easily completed by the 50 men told off for these duties.

Hence, with plenty of tools and materials prepared—pickaxes, shovels, wheelbarrows, planks, stockade timber, &c., such works as are here referred to should be completed in 8 or 10 days.

For their defence, let the outer line of trench have a man for every 4 feet; this will require 400 men; while there is a reserve of 250 to man the interior work, into which the larger party of 400 would retire in case of their work being forced: or a smaller detail may be given to the outer line of works, and a larger to the inner, according to circumstances and the judgment of the officer commanding.

The construction of the outer line of works in the form of a trench would only be resorted to in cases where the ground favoured such a profile, and where the inner line would have a good command over the outer one: but on level ground, the trench profile would be too weak to offer a good obstacle to a determined enemy; and would in that case require to be made of a good parapet and ditch before it.

When works are hastily thrown up, the vegetable mould, which is generally the best for forming the slopes, is covered by the inferior strata; when these latter are full of small stones, as is often the case, the earth first excavated should be thrown into the interior of the work, to be afterwards used as a cover for the parapet. If this precaution were not taken, many casualties might occur, from the effect produced by the enemy's shot striking on the stony surface of the parapet.

In selecting the site of a work, rocky situations but slightly covered with earth should be avoided.

From the commencement of the work, attention should be paid to the draining of its interior, which otherwise might soon be overflowed. When the work is open at the gorge, a small trench may be formed at the lowest part of it, and the terre-plein be sloped towards it. In enclosed works, a drain covered with flat stones or wood should be made, to convey the water from the lowest point of the interior into the ditch, taking care to prolong this species of tunnel with planks or other means beyond the base of the escarp, so that the water may not wear away that slope. A couple of planks may be nailed together to form a gutter, which can be let into the escarp slope, and the drain be made to empty itself into the gutter, the bottom of which should rest on a few flat stones or ends of fascines. When practicable, the ditches of field-works should also be drained from partial floods, otherwise the escarp and counterscarp slopes will not stand long, unless they be reveted.

In all cases, work should be given either by task or at a certain sum per cubic yard of excavation, &c.; for men will do much more when tasked than when paid by the day. If peasantry are employed, it is much better and cheaper to pay a high price for measured work than to employ them by the day.